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Association of Bay Area Governments, Berkeley, CA

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Volume 1: General Guidance for Nonattainment Areas

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Association of Bay Area Governments Project Manager: Eugene Leong
EPA Project Officer: Andrew Creekmore

16. ABSTRACT

This guideline presents information to assist States and local agencies in preparing ozone control strategies for nonattainment areas. The guidance should be most useful in preparing 1982 State Implementation Plan revisions.

The guideline covers the following topics: Intergovernmental Cooperation, Development and Assessment of Air Quality and Emissions Data, Modeling to Related Air Quality to Emissions, Control Strategy Analysis and Assessment, Plan Adoption, and the Continuing Planning Process. This volume covers general guidance to nonattainment areas.

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Association of Bay Area Governments
Hotel Claremont
Berkeley, California 94705

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Andrew T. Creekmore, Project Officer

Prepared for

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TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	LIST OF TABLES	v
	LIST OF FIGURES	vi
	GLOSSARY	vii
1.	INTRODUCTION	1-1
2.	SPECIAL PROBLEMS OF PHOTOCHEMICAL OXIDANT CONTROL	2-1
	Dynamics of Oxidant Formation	2-1
	Characterization of Sources	2-2
	Multiple Scales of Effect	2-3
	Institutional/Regulatory Implications	2-3
	References	2-5
3.	INTERGOVERNMENTAL COORDINATION AND PUBLIC INVOLVEMENT IN THE PLANNING PROCESS	3-1
	Requirements of the Clean Air Act	3-1
	State and Local Consultation Process	3-2
	Determination of Responsibilities	
	Local Lead Agency Designation	3-4
	Intergovernmental Coordination	3-5
	Public Participation	3-6
	References	3-9
4.	GENERAL TECHNICAL APPROACHES	4-1
	Various Levels of Analysis and the Corresponding Analysis Elements	4-2
	Level 1 Analysis	4-2
	Level 2 Analysis	4-6
	Level 3 Analysis	4-10
	Summary of Various Approaches	4-12

PAGE

4. General Guidelines for Technical Analysis 4-15

References 4-20

5. DETERMINING BASEYEAR OXIDANT CONCENTRATION 5-1

Interpretation of Air Quality and Ozone Standard 5-1

Determination of Design Value 5-2

References 5-3

6. EMISSION INVENTORY AND PROJECTION 6-1

Planning for Emission Inventory/Projection 6-2

Overview of Emission Inventory/Projection Process 6-5

Evaluation of Existing Emission Inventories 6-9

Determination of the Grid System 6-10

Data Collection 6-10

Data Analysis and Emissions Calculations 6-11

Spatial Resolution of Emissions 6-13

Temporal Resolution of Emissions 6-17

Emissions (VOC and NO_x) Species Allocation 6-18

Emission Projections 6-18

Problems 6-19

Guiding Principles 6-21

Overview of Projection Approaches 6-22

References 6-24

7. OXIDANT PREDICTION METHODS 7-1

Level 1: Photochemical Dispersion Models - Grid or Trajectory Models 7-1

General Description 7-1

Input Data Requirements 7-4

Model Validation 7-7

PAGE

7. Baseline Oxidant Predictions and Development of Alternative Emission Control Strategies 7-8

Sensitivity Analysis 7-8

Level 2: EKMA 7-9

General Description 7-9

EKMA Using Standard Isopleths 7-11

EKMA Using OZIPP-Generated Isopleths 7-12

Level 3: ROLLBACK 7-13

Application Procedure 7-13

References 7-15

8. DEVELOPMENT AND ASSESSMENT OF OXIDANT CONTROL STRATEGIES 8-1

Determination of Requirements for Oxidant Control 8-3

Inventory of Existing and Currently Scheduled Control Programs 8-4

Development of Candidate Control Measures, Including RACTs 8-5

Screening the Options 8-8

Selection and Definition of Alternative Control Strategies 8-9

Assessment of Alternative Control Strategies 8-10

Technical Effectiveness 8-11

Economic Considerations 8-11

Institutional Impacts 8-13

Overall Assessment 8-13

Staff-Recommended Control Plan 8-14

References 8-17

PAGE

9. PLAN REVIEW, ADOPTION AND APPROVAL PROCESS 9-1

Providing Adequate Time for Public Review 9-1

Availability of Review Documents 9-2

Demonstration of Reasonable Further Progress 9-2

Compliance with EPA RACT Measures 9-5

Demonstration of Legal, Financial and Manpower Commitment to Implementation 9-6

References 9-7

10. THE CONTINUING PLANNING PROCESS 10-1

Tracking Reasonable Further Progress 10-1

Work Program Submittals 10-4

APPENDIX A - BIBLIOGRAPHY OF URBAN SYSTEM MODELS A-1

APPENDIX B - EPA CONTROL TECHNOLOGY GUIDELINE DOCUMENTS B-1

List of Tables

Table		PAGE
2-1	Summary of Oxides of Nitrogen (NO_x) Control Issues in the Bay Area	2-4
3-1	Sample Division of Responsibilities for Non-Attainment Planning	3-7
4-1	Comparison of the Three Levels of Technical Analysis	4-13
6-1	Comparison of Three Different Levels of Emission Inventory	6-3
6-2	Comparison of Various Data Collection Techniques for Baseyear Emission Inventory	6-12
6-3	Alternative Methods for Spatial Distribution of Area Source Emissions	6-14
6-4	Comparison of Emissions Estimate Methods	6-16
8-1	Forthcoming CTGs for Stationary VOC Sources	8-6
8-2	List of Reasonably Available Transportation Control Measures	8-7
8-3	Washington Environmental Research Center (WERC) Matrix	8-15
8-4	Format of Decision Matrix Suggested in EPA AQMP Guidelines	8-16

List of Figures

Figure		PAGE
4-1	A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 1 Analysis Using Complex Models	4-4
4-2a	A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 3 Analysis Using EKMA Standard Curves	4-8
4-2b	A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 2 Analysis Using EKMA along with OZIPP Curves	4-9
4-3	A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 3 Analysis Using Rollback Model	4-11
6-1	Block Diagram for Aggregated Emission Inventory/ Projection Procedures	6-6
6-2	Block Diagram for Disaggregated Emission Inventory/ Projection Procedures	6-7
7-1	Example Ozone Isopleths Used in EKMA	7-10
8-1	Overview of Procedures for Developing Oxidant Control	8-2

GLOSSARY

The definition of acronyms and terms used in this document are given below.

ABAG:	Association of Bay Area Governments
APCD:	Air Pollution Control District
AQMD:	Air Quality Management District
AP-42:	EPA document, Compilation of Air Pollutant Emission Factors, including supplements
CARB or ARB:	California Air Resources Board
CFR:	Code of Federal Regulations
COG:	Council of Governments
EIS:	Emission Inventory System. (This term refers to the system used by the U.S. Environmental Protection Agency.)
EKMA:	Empirical Kinetic Modeling Approach
ELSTAR:	Environmental Lagrangian Simulator of Transport and Atmospheric Reactions
EPA:	U.S. Environmental Protection Agency
HC:	hydrocarbons
Level:	three levels of sophistication are given for the oxidant modeling approaches; Levels 1, 2, and 3 are characterized as complex, intermediate, and simple, respectively.
LIRAQ:	Livermore Regional Air Quality Model
MTC:	Metropolitan Transportation Commission
MPO:	Metropolitan Planning Organization
NEDS:	National Emission Data System
NMHC:	Non-methane hydrocarbons
NOx:	Oxides of Nitrogen
OPR:	Oxidant Prediction Relationship
OZIPP:	EPA's Kinetics Model and Ozone Isopleth Plotting Package

ppm:	parts per million
RACM:	Reasonably available control measure
RACT:	Reasonably available control technology
RATCM:	Reasonably available transportation control measure
SIP:	State Implementation Plan
UTM:	Universal Transverse Mercator Coordinate System
VMT:	Vehicle miles travelled
VOC:	Volatile organic compounds

Chapter 1

INTRODUCTION

The Clean Air Act Amendments of 1977 continue the requirement for State Implementation Plans (SIP) to be prepared to attain and maintain national ambient air quality standards. For a variety of reasons, the deadlines for submittal of the SIP's and the dates by which the plans are to demonstrate meeting the various air quality standards have been revised. Wherever possible, SIP's are to show meeting all applicable standards no later than 1982. For carbon monoxide and photochemical oxidants, under specific conditions, a five-year extension to 1987 is possible.

An important factor in determining what strategies are needed in an air quality plan is the level at which air quality standards are set. Recently, for example, the Environmental Protection Agency changed the photochemical oxidant 0.08 parts per million (ppm) - 1-hour standard to an ozone (0) 0.12 ppm - 1-hour standard. At the time the Bay Area non-attainment plan was adopted locally, the oxidant standard was still 0.08 ppm; therefore, the plan was developed to meet this standard. Although the standard has been changed to 0.12 ppm, the techniques used to develop the control strategy for the study are still valid. Currently, the Bay Area is re-examining its adopted plan to see what changes are appropriate. Other non-attainment areas may prepare plans for the new standard.

These reports have been prepared to assist those involved in preparing non-attainment plans for use in SIP submittals. Specifically, the reports deal with preparing photochemical oxidant or ozone control strategy plans. Depending on where a particular region is in the development of its plan(s), these guidance materials should be useful for the 1982 SIP submittals.

Volume I provides general guidance to non-attainment oxidant areas. This guidance is sufficiently broad in scope that all areas experiencing oxidant problems should find the report to be useful. Discussions are presented on the technical procedures for analyzing the oxidant problem and alternative control strategies. The intergovernmental coordination and public involvement required in the planning process are similarly described. A systematic approach to plan development is given. This approach acknowledges the widespread differences experienced across the nation in the extent and severity of oxidant air pollution. Three different levels of analysis are proposed depending on regional availability of data, staff and budgetary resources, and overall schedules for plan preparation. These three levels of analysis vary in the degree of sophistication of the models employed for land use and transportation simulation, emission inventories, and oxidant predictions. The modeling approaches can be broadly characterized as complex, intermediate and simple. The confidence and accuracy of technical analysis should be proportional to the degree of sophistication of the models used and the amount of effort expended in modeling. As conclusions and recommendations derived from the technical analysis are often important and costly, emphasis of this guideline is placed on analyses using complex or intermediate models to obtain more accurate results. The simple models, e.g., rollback technique, are discussed only for the purpose of preliminary assessment.

Volume II documents the results of a planning program to develop an oxidant plan for the San Francisco Bay Area during the period from 1976 to 1978. This volume is a detailed case study of the planning process, analysis procedures and development of final plan recommendations.

Volume II is intended primarily for air quality planners and/or technical personnel. As other non-attainment areas embark on similar planning programs, the recent experiences of the Bay Area should be instructive. The Bay Area efforts attempted to maintain an open and highly visible process for developing the plan. At the same time, the technical approach and analytical methodologies were as rigorous and objective as possible given the staff and budgetary resources available to the program. Throughout the plan development as both process and products were balanced, lessons were learned for conducting similar work in the future. The documentation of these lessons learned in the Bay Area--what to do and what not to do--is a major purpose of this report.

Chapter 2

SPECIAL PROBLEMS OF PHOTOCHEMICAL OXIDANT CONTROL

The special problems of oxidant control can be categorized under the following headings:

- Dynamics of Oxidant Formation
- Characterization of Sources
- Multiple Scales of Effect
- Institutional/Regulatory Implications

DYNAMICS OF OXIDANT FORMATION

Oxidants in urban areas result primarily from complex interactions among reactive hydrocarbons and nitrogen oxides in the presence of sunlight. The magnitude and distribution of oxidant in an urban area are affected by a number of factors, including: 1) the amount and distribution (spatial and temporal) of emissions of reactive hydrocarbons and oxides of nitrogen; 2) composition of reactive hydrocarbons; 3) meteorological and topographical conditions; and 4) other factors, such as background conditions. A reasonable degree of technical understanding of the dynamics of oxidant formation is considered crucial to establishing the technical credibility of the oxidant non-attainment planning effort. Detailed discussions of the dynamics of oxidant formation may be found in References 2-1, 2-2, and 2-3. The dynamics of oxidant formation can be simulated by sophisticated, "state-of-the-art" photochemical dispersion models, which are very data-intensive and resource-intensive. On the other hand, simplified oxidant models are available which are relatively easy to apply but do not consider the complicated photochemical reactions. The level of accuracy desired for oxidant modeling must be evaluated against the resources (money, skill, manpower and equipment) available, overall schedule for the planning effort, and other factors.

CHARACTERIZATION OF SOURCES

The characterizing of sources leading to oxidant formation in an urban area has been an area of research for many years. Generally speaking, oxidant concentrations measured in an urban area may be attributable to the following sources:

- emissions of man-made organic and nitrogen compounds from the study area
- emissions of natural organic and nitrogen compounds from the study area
- oxidant (and/or precursors) transported from areas outside the study area.

Relative levels of oxidant resulting from each of these three sources will significantly affect the planning strategy for attainment and maintenance of oxidant standards. Unfortunately, detailed information on the relative contributions of various sources to oxidant formation is not available for most non-attainment areas. Based on the most recent studies of this issue, the U.S. Environmental Protection Agency has suggested in a draft policy statement that a natural background concentration of 0.04 ppm oxidant be assumed for the purpose of control strategy planning (2-4). Further investigations of the sources of oxidant precursors and their chemistry, meteorological effects, and long-range transport of oxidant and precursors are necessary in order to better understand and control the oxidant problems.

MULTIPLE SCALES OF EFFECT

The multiple geographical scales of photochemical oxidant impact was an issue which surfaced in the oxidant modeling analysis in the San Francisco Bay Area (2-5). The LIRAQ model was used to test the sensitivity of maximum oxidant levels to changes in hydrocarbon and nitrogen oxides emission levels. As an example, Table 2-1 summarizes what is known and what is suspected in regard to the effects of further control of NO_x emission on oxidant levels in the San Francisco Bay Area.

The LIRAQ sensitivity analysis indicates that further NOx control will result in higher oxidant levels within the region than would occur with a "hydrocarbon only" control strategy. On the other hand, by not controlling nitrogen oxides, it is suspected that the oxidant problem of the Bay Area may be transported to a neighboring airshed (e.g., to Sacramento, 90 miles to the northeast, or to Monterey, 70 miles to the south). The implications to be drawn are that hydrocarbons should be stringently controlled and that care should be exercised in deciding the appropriate degree of nitrogen oxides emissions control.

EPA is continuing studies of this O_3/NO_x relationship and the control strategy implications likely to result from additional information.

INSTITUTIONAL/REGULATORY IMPLICATIONS

A number of agencies have direct control over air pollution sources. Many other agencies affect air quality indirectly through agency policies. A non-attainment area plan must be concerned with both direct and indirect causes of the oxidant problem. In other words, both

TABLE 2.1 Summary of Oxides of Nitrogen (NO_x) Control Issue in the Bay Area

	THE IMPACTS OF ADDITIONAL NO_x CONTROLS		THE IMPACTS OF NO ADDITIONAL NO_x CONTROLS	
	Within the Bay Area	Outside the Bay Area	Within the Bay Area	Outside the Bay Area
OXIDANT AIR QUALITY	LIRAQ analysis indicates that higher levels of oxidant occur with NO_x controls in the proposed comprehensive strategy.	It is suspected that downwind areas where transport may contribute to existing oxidant problems would be improved.	LIRAQ analysis indicates that lower levels of oxidant occur with no NO_x controls in the proposed comprehensive strategy.	It is suspected that downwind areas where transport may contribute to existing problems would experience worse oxidant air quality.
NITROGEN DIOXIDE (NO2) AIR QUALITY	May reduce NO_2 violations if appropriate controls can be identified, e.g., stationary vs. mobile and ground level vs. elevated emissions.	Not of concern (no NO_x violations are recorded in neighboring air basins).	NO_x emissions are projected to be relatively constant between 1975-2000. However, the relative contributions from mobile sources and industry change substantially. NO_2 violations may decrease as the motor vehicle NO_x emissions decrease by 2000.	Not of concern (no NO_2 violations are recorded in neighboring air basins).

control strategies and policies influencing air quality should be dealt with, and all agencies involved directly and indirectly should be coordinated and consulted in the planning process. The Clean Air Act is explicit in the requirements that each plan provide for the exchange of information and identification of intergovernmental responsibilities as necessary to develop and implement the plan. Unless all agencies involved are well coordinated, any proposed oxidant control program may create conflicts between the various agencies over responsibilities, jurisdiction, control philosophy, etc. Institutional coordination and cooperation is an important part of the air quality planning. Chapter 3 of this guidance addresses the various aspects of this issue.

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Chapter 3

INTERGOVERNMENT COORDINATION AND PUBLIC INVOLVEMENT IN THE PLANNING PROCESS

Central to the success or failure of air quality planning in non-attainment areas is the intergovernmental coordination and local and public involvement necessary to begin and carry out the planning program. This chapter briefly describes key requirements of the 1977 Clean Air Act with respect to intergovernmental coordination and public involvement. It also covers some important organizational aspects of an air quality planning program in non-attainment regions. For additional information, earlier EPA guidance materials on these topics are also available (3-1, 3-2).

REQUIREMENTS OF THE CLEAN AIR ACT

The Clean Air Act Amendments of 1977--as did the previous version of the Act--require the development of air quality plans in regions where the national ambient air quality standards are not being achieved. The 1977 Amendments, however, go much further than previous legislation in specifying the content and organizational requirements to preparing such plans. For example, the 1977 Act also specified that, where possible, the non-attainment plan is to be prepared by an organization of elected officials of local governments. Section 174 further specified that, where feasible, the agency designated to prepare the revised implementation plan shall be the metropolitan planning organization (transportation planning) or the organization responsible for air quality maintenance planning, or the organization with both responsibilities. The language noted above contains a great deal of flexibility for states and local governments to determine how such plans are to be prepared.

STATE AND LOCAL CONSULTATION PROCESS

Section 121 of the 1977 Amendments ensures an orderly process for organizing and carrying out the planning process. The section provides that each State shall provide a "satisfactory" process of consultation with general purpose local governments and designated air quality planning organizations of local elected officials. The consultation process covers the actual process of designation of agencies under S. 174 of the Act and the process of developing plans required by the Act.

A consultation process for plan preparation is defined in EPA regulations (40 CFR Part 51) as satisfactory if it includes:

- Information dissemination and education of relevant organizations and individuals
- Opportunity for involvement of affected governmental organizations and elected officials
- Opportunity for joint resolution by affected governmental organizations and individuals on key issues (including selection of control strategies, especially those requiring local enforcement, implementation or commitment of resources).

The regulations on intergovernmental consultation also provide for coordination of other Federally assisted regional planning programs, State and areawide clearinghouse review, summaries of plan development, and public and agency participation.

DETERMINATION OF RESPONSIBILITIES

Although it is readily apparent from the 1977 amendments that the states continue to be responsible for adoption of the State Implementation Plans, the partnership emphasis of the 1977 Amendments presents the states and local agencies with a wide array of choices about assigning planning tasks. Among the regulatory requirements under S. 121 is that the governor of each state discuss the "alternatives investigated for consolidation of environmental and other planning functions."

In determining responsibilities to be divided, a number of different approaches can be taken. The central features of any planning process as rigorous as that required by the Clean Air Act are these:

- Technical analysis (including baseline emission inventory, future emission inventory projections, oxidant prediction, modeling)
- Control strategy analysis (including assessment of effectiveness, costs, and environmental, social and economic effects)
- Public participation
- Plan review and adoption

The more complicated the organizational setting, the less readily apparent will be the division of responsibility. For example, in a state where a branch of state government serves as an air pollution control agency and has authority over a wide variety of air pollution sources, but where there is no comparable local regulatory agency, the state may play a more significant role in planning than in a state where local/regional agencies are more capable of performing of the necessary tasks.

Another example of the decisions to be made in the process of "joint determination" is what pollutants to cover. For example, some states have chosen to interpret various provisions of the Act to mean that they (the states) have responsibility over total suspended particulates and sulfur dioxide--with local governments' tasks covering the transportation-related pollutants (hydrocarbon, nitrogen oxides and carbon monoxide). Other states have determined it appropriate to have local agencies deal with all pollutants where a standard is violated. As long as a plan is prepared to meet the requirements of the law, however, how such a plan is prepared will depend on the desires of both state and local officials. Wherever a local agency has demonstrated a willingness or capability to address all pollutants, it makes sense that they do so, because a single, coordinated planning and public participation process can be used to examine alternative controls and assess their costs and benefits. It also tends to present information in a standardized fashion to improve public understanding.

LOCAL LEAD AGENCY DESIGNATION

Although the Act itself does not use the phrase "lead agency" the concept of a lead agency is used in EPA's S. 121 regulations. The responsibility for ensuring satisfactory intergovernmental consultation is assigned by the regulations to any governmental organization that has the "lead responsibility for development" of any of the following implementation plan elements:

- Procedures for pre-construction review of direct sources
- Transportation-related control measures
- Control measures other than transportation-related measures.
- Measures for prevention of significant deterioration of air quality and protection of visibility
- Air quality maintenance measures

- Delayed compliance orders under S. 113 (d).

The regulations, therefore, contemplate substantial involvement in the planning process by many agencies.

INTERGOVERNMENTAL COORDINATION

In many respects the 1977 amendments and EPA's implementing regulations recognize the intergovernmental complexities of most of the nation's metropolitan areas, and the varying degrees of organizational levels in the different states.

In most states there is no single statewide agency responsible for both air pollution controls and transportation. Thus, just as there is a national interagency agreement on air quality/transportation coordination, there may have to be state-level agreements between a state transportation agency and the state air pollution control agency. Similar agreements might be necessary or desirable to coordinate air quality activities with energy facility siting agencies.

At the metropolitan level, similar coordination activities will be required. For example, at least 10 of the states have designated air quality planning organizations that are not metropolitan planning organizations in their respective urban areas. These states include California, Illinois, Montana, Nevada, New York, Ohio, Pennsylvania, South Carolina, Virginia and Washington.

Another example where coordination is needed is for stationary and mobile sources. In many states--California is one example--mobile source controls are the sole responsibility of the state. Regional or local air quality regulatory agencies may exist independent of areawide planning organizations.

In most areas, sucessful air quality planning will require extensive cooperation among local, regional and state agencies. The coordination and organizational cooperation needed will vary from region to region, reflecting differing organizational authority and air quality planning capability. Table 3-1 depicts a sample division of responsibilities for non-attainment planning purposes. It is intended only to illustrate the kinds of determinations that should occur during the initial planning period, before the technical analysis begins.

PUBLIC PARTICIPATION

Most Federal programs, including those of EPA, require public participation as an integral part of planning. As noted previously in this chapter, the "intergovernmental consultation" requirements generally apply to parties interested in or affected by the air quality planning provisions.

Numerous techniques for public participation programs are available; most are familiar to organizations and agencies experienced with Federal programs. What techniques are chosen for the air quality planning programs should be an essential feature of the designated agency's overall public participation efforts. Goals and objectives of the public participation program should be defined in measureable terms, and the overall project budget should adequately support a well-designed public participation program. A central feature of the public participation program should be evaluation of its strengths and weaknesses during the planning project so that, as problems occur, they can be corrected.

Table 3-1

Sample Division of Responsibilities for Non-Attainment Planning

Program Component	Responsible Agency
Planning Coordination/Program Management	Council of governments (COG)
Provision of Policy Guidance Task Force	COG
Organization of Public Participation Program	COG
Organization of Joint Technical Staff	COG
Development of regional land use and population activity forecasts	COG
Analysis and monitoring of effects of land uses on air quality	COG
Monitoring and data analysis of ambient air quality and related meteorology	Local air pollution control district (APCD)
Maintenance of emissions inventory for modeling purposes, assessment of emission trends and projection of future emissions for non-vehicular sources	APCD
Assessment of air quality trends and projections of future air quality	APCD
Development, analysis and monitoring of stationary source control measures	APCD
Preparation, adoption and enforcement of stationary source control measures	APCD
Air quality impact analysis for proposed projects	APCD
Development of regional transportation policies and plans	Metropolitan planning organization for transportation (MPO)

Program Component	Responsible Agency
Development of regional travel demand forecasts	MPO
Development, analysis and monitoring of transportation control measures	MPO
Projection of emissions from transportation sources	MPO
Adoption of Mobile Source Control Measures	State air pollution agency
Overall review and coordination of air quality planning effort (data analysis, modeling, control strategy development and assessment)	COG
Analysis of plan's environmental, social and economic impacts	COG
Plan adoption and submittal to Air Resources Board	COG

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3-3 U.S. Environmental Protection Agency, "Requirements for Preparation, Adoption and Submittal of Implementation Plans", 40 CFR Part 51, Subpart M (Intergovernmental Cooperation), May 1978.

Chapter 4

GENERAL TECHNICAL APPROACHES

This chapter discusses planning of the technical analysis for oxidant control programs. As there is a great variation among non-attainment areas with respect to the magnitude of the oxidant problem and resources available for plan preparation, the technical approaches presented are deliberately general and flexible. In order to be useful to a variety of non-attainment areas, three different levels of technical analysis are discussed. These three levels of analysis vary in the degree of sophistication between the models used, and involve different levels of available resources (manpower, money, time, skill and equipment). The accuracy of the technical analysis generally increases as the level of effort increases. However, there are other factors to be considered in selecting the level of analysis for a non-attainment area. The following section describes these three general technical approaches which can be used in non-attainment planning and analysis. The subsequent section summarizes and compares various technical approaches. The last section of this chapter presents several general guidelines, which if followed, can help improve the technical credibility of a non-attainment planning analysis. More specific guidelines to each technical analysis element, e.g., compiling emissions inventory, are discussed in other chapters of this guidance.

It should be pointed out that the U.S. EPA is currently developing a guidance specifying what levels of ozone modeling analysis various non-attainment areas should undertake for the 1982 SIP's. Five levels of analysis are under consideration. These include:

Level 1 - Photochemical Grid Models

Level 2 - Photochemical Trajectory Models
(Including Intensive City-Specific EKMA)

Level 3 - Application of Basic City-Specific EKMA

Level 4 - Application of Standard EKMA, and

Level 5 - Application of Rollback Model.

The U.S. EPA is also considering various criteria which should be used in selecting an appropriate level of analysis.

VARIOUS LEVELS OF ANALYSIS AND THE CORRESPONDING ANALYSIS ELEMENTS

An overview of the three different technical approaches to oxidant planning and analysis are given in this section. For each technical approach, a simplified flow diagram for major analysis tasks is presented. These flow diagrams illustrate where to start a technical analysis for oxidants, what tasks are involved and the interrelationship and time sequence of those tasks. The major analysis elements involved in each level of analysis are also briefly discussed. The information provided is intended to give readers a clear understanding of the analysis process involved. They will be useful to the project manager in developing project organization and in preparing a detailed management plan for conducting the technical analysis.

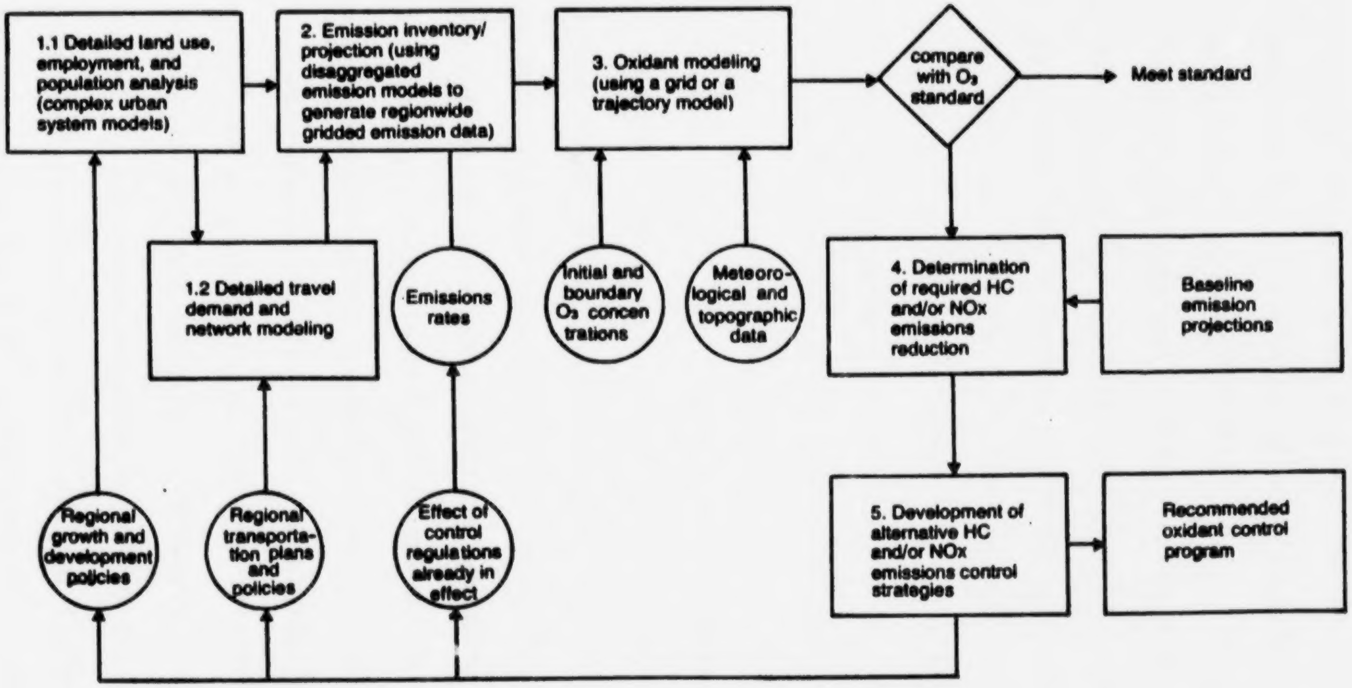
LEVEL 1 ANALYSIS

The Level 1 analysis involves the most detailed techniques considered to be available. It employs a grid-based photochemical dispersion model such as LIRAQ (4-1) or SAI (4-2), or a trajectory model such as ELSTAR (4-3), as the primary tool for oxidant control analysis.

Because of the extensive input data required by the oxidant prediction model, high levels of effort (manpower, time, skill, etc.) are needed to carry out this level of analysis. This analysis may provide the most accurate answers to a number of non-attainment planning questions. Figure 4-1 is a simplified flow diagram illustrating the analysis process and specific tasks involved. As noted, there are five major tasks involved in one analysis cycle. The initial cycle begins with land use, economic, demographic and transportation analyses in order to determine urban activity levels. Then the emission inventories and projections are made based on regional activity levels and emissions data. As required by the photochemical dispersion model, spatial and temporal resolution of emissions and species allocation of organic (and/or NOx) emissions are conducted. The next task is to predict oxidant concentrations using a selected photochemical model. The additional inputs required (e.g., meteorological and topographical data, and initial and boundary emission concentrations) are prepared. By comparing predicted oxidant concentrations with the oxidant standard, the emission reductions necessary to attain the standard are determined.

At the end of the initial analysis cycle, candidate oxidant control strategies are developed. The effectiveness of emission reductions of candidate control strategies are assessed. Then, a new set of regionwide gridded emission data is developed by considering the emission reductions resulting from the selected control strategies. With the new set of emission data, a second analysis cycle is initiated to analyze the effect of the selected control strategies on regional oxidant concentrations. This cycle is repeated to evaluate various oxidant control packages until an appropriate control package is

Figure 4-1 **A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 1 Analysis Using Complex Models***


1.1 Detailed land use, employment, and population analysis (complex urban system models)
2. Emission inventory/ projection (using disaggregated emission models to generate regionwide gridded emission data)
3. Oxidant modeling (using a grid or a trajectory model)
compare with O_3 standard
Meet standard
1.2 Detailed travel demand and network modeling
Emissions rates
Initial and boundary O_3 concentrations
Meteorological and topographic data
4. Determination of required HC and/or NOx emissions reduction
Baseline emission projections
Regional growth and development policies
Regional transportation plans and policies
Effect of control regulations already in effect
5. Development of alternative HC and/or NOx emissions control strategies
Recommended oxidant control program

*This is the level of analysis used in the non-attainment planning analysis in the San Francisco Bay Area.

selected.

The five major tasks included in one technical analysis cycle are summarized in terms of their purposes and products in the following paragraphs. More detailed guidelines for each specific task are discussed in Chapters 5, 6, 7 and 8 of this guidance.

Task 1.1: Land Use, Economic and Demographic Analysis

The purpose of this task is to estimate present and future levels of urban activity for traffic analysis and emission inventory preparation. This task is generally conducted by regional and local planning agencies. To project regional land use, employment, population and housing, a number of models may be used (EAAM, PLUM, USM, ALDM, LUAM, LUPDM, NBER-USM, ITL4SMP, BEMOD, etc., see Appendix A). Since a disaggregated emission inventory is required by the photochemical model, the result of this task is a set of disaggregated employment, population, and land use data suitable for use in preparing the emission inventory.

Task 1.2: Travel Demand and Network Analysis

The purpose of this task is to generate the travel data necessary for projecting transportation-related emissions. Using the outputs of Task 1.1, and present and future transportation networks and travel assumptions, this task generates the traffic volumes and average speed for each segment in the regional network. Trip generation data are also generated in this task. A number of common travel demand models (trip generation model, trip distribution model, modal choice model, network assignment model, etc.), may be used for the analysis. (See Appendix A.) In areas where there is a high level of air travel activity, air travel may be considered separately from ground travel.

Task 2: Emissions Inventory/Projections

Based on the urban activity data generated in Tasks 1.1 and 1.2, this task projects emissions inventories for the baseyear and selected future years. The level of detail of the emissions inventory must be consistent with the requirement of the photochemical model to be used. At this level of analysis, a grid model or a less complex trajectory model may be used. A grid model requires a spatial and temporal resolution of emissions inventory, while a trajectory model considers only the pollutants emitted into the air parcel along the trajectory path. Both types of model require that the emissions be broken down into certain species classes.

Task 3: Prediction of Peak Oxidant Concentrations

This task is to estimate peak oxidant levels in the non-attainment area in order to calculate the required emission reductions. This task includes preparation of inputs, execution of computer modeling, and interpretation of modeling results. In addition to emissions data, a grid or trajectory model will require several types of inputs. This may include:

- Meteorological data - wind speed, wind direction, mixing height, etc.
- Sun radiation data - Light intensity, etc.
- Topographical data, and/or
- Initial and boundary ozone concentrations (or natural and transported ozone concentrations)

Detailed guidance to photochemical modeling is presented in Chapter 7 of this document. The peak oxidant concentrations determined from computer modeling are used as a basis for calculating emissions reductions required and developing oxidant control strategies in the following tasks.

Task 4: Determination of Emissions Reductions

By comparing the estimated peak oxidant level to the oxidant standard, the emission reductions required to attain air quality standards can be calculated. The required reductions establish the goal for developing various oxidant control strategies.

Task 5: Development of Oxidant Control Strategies

Alternative oxidant control strategies are developed and assessed in this task. The developed control strategies should demonstrate that the oxidant standard will be attained as expeditiously as practicable, but no later than 1987.

LEVEL 2 ANALYSIS

This level of analysis employs a less complex model, i.e., EPA's

Empirical Kinetic Modeling Approach (EKMA) (4-4), to estimate the required oxidant controls. There are two types of EKMA which should be distinguished. The standard EKMA uses a standard set of ozone isopleths to calculate the required ozone control (4-4). Another EKMA uses the Kinetics Model and Ozone Isopleth Plotting Package (OZIPP) to calculate maximum one-hour average ozone concentrations for the non-attainment area (4-5). The OZIPP is a "trajectory" photochemical model, and requires a number of city-specific inputs, including initial precursor concentrations, light intensity, dilution, diurnal and spatial emission patterns, transported ozone concentrations and reactivity of the precursor mix. The results of OZIPP simulations are used to produce an ozone isopleth diagram. This diagram is then used in EKMA procedure to calculate the necessary ozone controls.

Figure 4-2a shows a simplified flow diagram for the standard EKMA procedure. This procedure uses a standard set of ozone isopleths to determine the HC and/or NO_x emission reduction required to attain the ozone standard. The standard ozone isopleths were developed by EPA based on fixed assumptions of sunlight intensity, atmospheric dilution rate, reactivity and diurnal emission patterns. For this reason the standard EKMA has relatively limited flexibility in application and cannot treat city-specific factors such as emission patterns or meteorological conditions. Nevertheless, transported ozone concentration can be crudely treated by this method using a modified procedure.

Figure 4-2b shows a flow diagram for EKMA using OZIPP. The initial task is to collect data for baseyear emissions inventory and to estimate future land use, economic, demographic data and future transportation

Figure 4-2a **A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 2 Analysis Using EKMA Standard Curves**

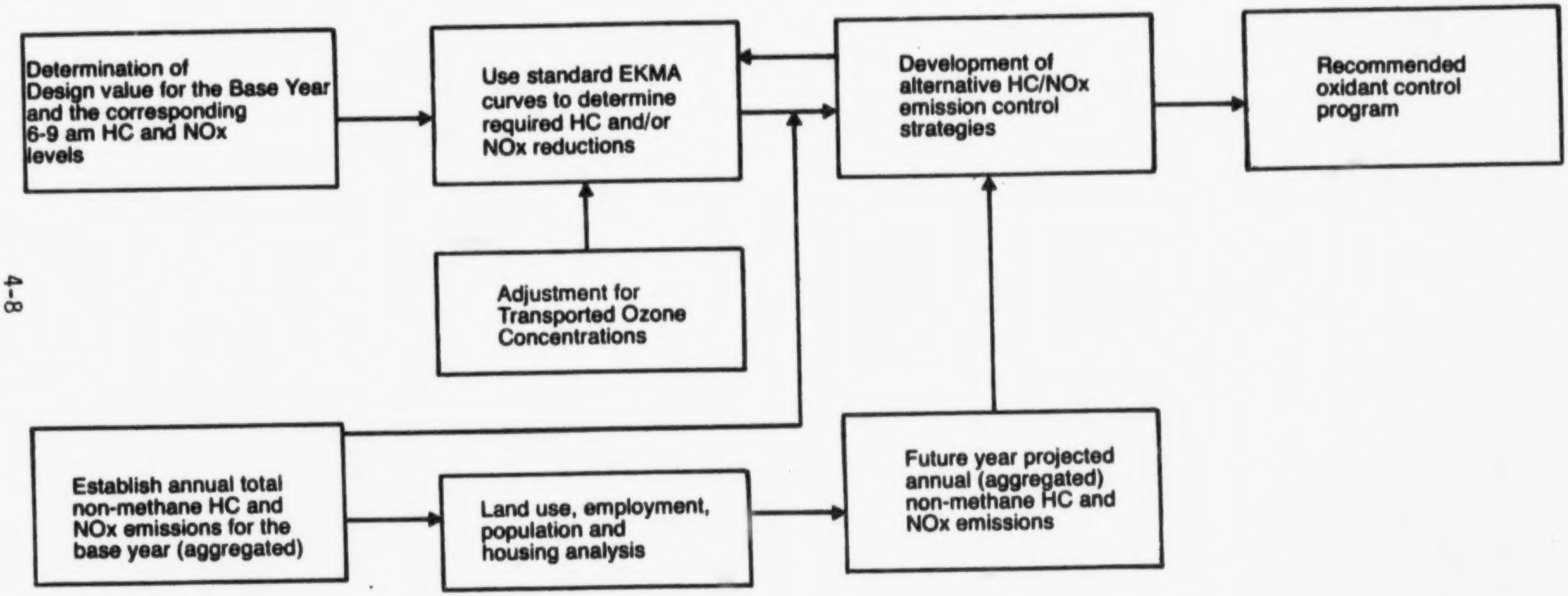
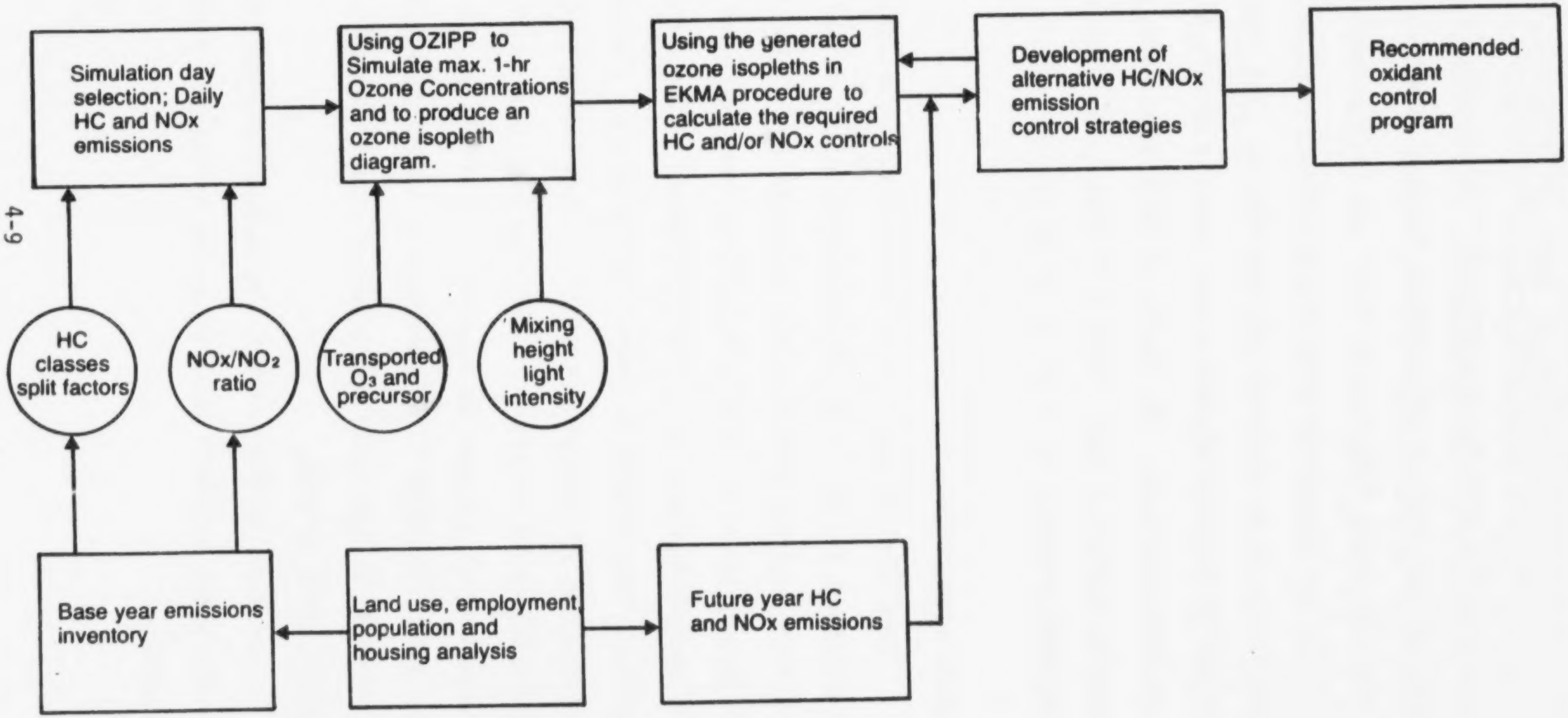

Determination of Design value for the Base Year and the corresponding 6-9 am HC and NOx levels
Use standard EKMA curves to determine required HC and/or NOx reductions
Development of alternative HC/NOx emission control strategies
Recommended oxidant control program
Adjustment for Transported Ozone Concentrations
Establish annual total non-methane HC and NOx emissions for the base year (aggregated)
Land use, employment, population and housing analysis
Future year projected annual (aggregated) non-methane HC and NOx emissions

Figure 4-2b **A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 2 Analysis Using EKMA along with OZIPP**


Simulation day selection; Daily HC and NOx emissions
Using OZIPP to Simulate max. 1-hr Ozone Concentrations and to produce an ozone isopleth diagram.
Using the generated ozone isopleths in EKMA procedure to calculate the required HC and/or NOx controls
Development of alternative HC/NOx emission control strategies
Recommended oxidant control program
HC classes split factors
NOx/NO2 ratio
Transported O3 and precursor
Mixing height light intensity
Base year emissions inventory
Land use, employment, population and housing analysis
Future year HC and NOx emissions

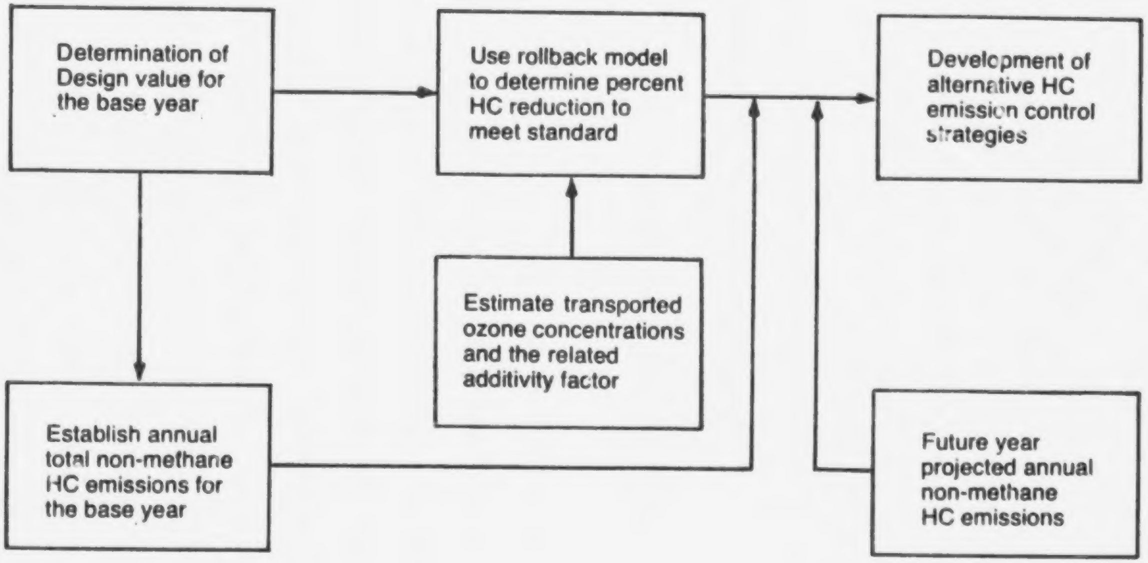
activity for emission projections. As required by the OZIPP, the diurnal and spatial distribution pattern of emissions are estimated. Other input data required by OZIPP are also prepared; this includes natural and transported ozone concentrations, light intensity, dilution, reactivity of the precursor mix, and others. The next task is to use OZIPP to simulate maximum 1-hour average ozone concentrations in the non-attainment area. The results of OZIPP simulations are subsequently used to produce an ozone isopleth diagram. This diagram is then used in the EKMA procedure to calculate the necessary HC and/or NO_x reductions.

LEVEL 3 ANALYSIS

This level of analysis uses a simple technique, i.e., rollback technique (4-4), to estimate the necessary emissions reductions. Rollback requires even less data than EKMA used in the Level 2 analysis. A flow diagram for Level 3 analysis is shown in Figure 4-3. This level of analysis may also be a possible alternative for estimating bounds on control requirements for hydrocarbon emissions. The rollback technique is based on the assumption that a fractional reduction in hydrocarbon emissions will result in an identical reduction in the maximum oxidant concentration; it does not consider the effect of nitrogen oxides on oxidant formation. Thus the application of the rollback technique is limited to a first order approximation, and is viewed by many to be of questionable validity.

Using the rollback method, the HC emission reduction necessary to achieve the oxidant standard can be calculated using the following equations:

Figure 4-3 **A Simplified Flow Diagram for O_3 Non-attainment Planning Analysis: Level 3 Analysis Using Rollback Model**


Determination of Design value for the base year
Use rollback model to determine percent HC reduction to meet standard
Development of alternative HC emission control strategies
Estimate transported ozone concentrations and the related additivity factor
Establish annual total non-methane HC emissions for the base year
Future year projected annual non-methane HC emissions

$$R = \frac{(O_3)adj - X}{(O_3)adj}$$

$$(O_3)adj = (O_3)design - A(To)$$

where

$(O_3)adj$ = the adjusted ozone concentration to be used in estimating control requirements;

(O_3) design = the O_3 design value for the base period;

X = a specified air quality goal, usually the ozone standard;

A = the additivity factor for transported ozone;

To = the concentration of transported ozone estimated for the base period;

R = the emission reduction required.

SUMMARY OF VARIOUS APPROACHES

In a non-attainment planning effort, technical analysis of oxidant concentrations and estimated emissions reduction requirements serve as the basis for formulating needed oxidant control strategies. The adopted oxidant control program usually involves costly or controversial emission control measures. Thus, selection of an appropriate level of technical analysis is important. Table 4-1 summarizes the advantages and disadvantages of the above-mentioned three levels of technical analysis. The major tasks involved in each of the three levels of analysis are also compared in the table.

Table 4-1. Comparison of the Three Levels of Technical Analysis*

Level of Analysis	Land use, employment, population and transportation analysis	Emission projection/inventory	Oxidant prediction methods	Determination of emission reductions; Development of control strategy	Advantages of OPR Used	Disadvantages of OPR Used
1	• Use computer models to estimate size and distribution of urban activities.	• Use computer models to generate spacial and temporal distribution of HC and NO_x emissions. HC and/or NO_x emissions have to be divided into species classes.	• Use a grid-based or a trajectory photochemical dispersion model to estimate regionwide gridded oxidant concentrations. • Consider complex topography, meteorology, source distribution, and transported ozone concentrations.	• Consider a variety of HC and NO_x emission control strategies (e.g., spatially or temporally variable controls).	• The models have the highest potential for validation with observed oxidant concentrations. • Can provide estimates of magnitude, location and time period of the peak oxidant concentrations. • Consider composition of HC and treat NO_x emissions; treat spatial and temporal distributions and transport of constituents; consider background concentrations • Capable of evaluating a wide range of oxidant control strategies such as emission reduction at specific sources, emission controls at certain locations or time periods, HC emissions control combined with NO_x emission control, etc.	• Data requirements are very extensive; great amount of manpower, time and money required to prepare the inputs. • Expensive to execute the model (cost is on the order of $500 per run); computer with large storage capacity is required • Require experienced personnel to perform the modeling; difficult to interpret the model's outputs
2	• Use less complex models to estimate levels of urban activities at county or county-equivalent level.	• Use manual or computer models to estimate aggregated HC & NO_x emissions; relative distribution patterns of emission on simulation day are required.	• Use EPA's EKMA to relate oxidant levels to precursors concentrations. • EKMA cannot predict absolute ambient oxidant concentrations; OZIPP may be used to estimate ambient ozone concentrations • Transported ozone can be crudely treated	• Consider total HC and/or NO_x emission reductions. • Treat limited HC and/or NO_x control measures.	• Less extensive data requirements • Relatively easy to prepare the inputs and apply the model • Can evaluate certain types of oxidant control strategies • Consider the effect of both HC and NO_x and O_3 levels; allow for consideration of background concentrations	• Model more difficult to validate. • Analysis agrees with smog chamber experiments; accuracy in atmosphere may not be good because of gross simplification of meteorology. • Relatively limited application for oxidant control evaluation • Is not feasible to apply the EKMA in areas where the observed HC/NO_x ratio is low ($<2:1$)
3	• Use simple techniques to estimate levels of activities at county or county-equivalent level.	• Aggregated HC emissions for the study area are needed.	• Cannot predict oxidant concentrations. • Use modified rollback technique to determine emission reductions required. • Transported ozone can be crudely treated.	• Consider total HC emission reductions only.	• Easy to apply	• Does not consider NO_x emissions; does not treat spatial or temporal distribution of HC emissions • Model is not verified • Can only be used as a first order approximation

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* Technical analysis includes 1) analysis of urban activities, 2) emission inventory and projection, 3) oxidant prediction and 4) determination of oxidant control requirements. The results of technical analysis provide a basis for developing alternative control strategies.

As noted, the advantages of the Level 1 analysis include a high level of sophistication, completeness and accuracy. The oxidant analysis results can be verified with observed concentrations and a wide range of HC and NO_x emission control strategies can be evaluated. This level of analysis was selected and successfully carried out in several air quality maintenance areas such as San Francisco and Denver. However, the emissions and meteorological data required are very extensive and a substantial amount of manpower, time and money is needed to perform the analysis.

Level 2 analysis may use either the standard EKMA or OZIPP-EKMA procedures to determine the required emission reductions. Both EKMA procedures are the result of several years of studies conducted by the U.S. EPA. The standard EKMA requires less extensive data and is a less time-consuming technique, but has relatively limited flexibility in application. The OZIPP-EKMA procedure is more complicated, and requires a computer facility to execute the OZIPP and to plot an ozone isopleth diagram. City-specific factors are considered in the OZIPP-EKMA procedure. In general, the Level 2 analysis, especially the OZIPP-EKMA procedure, may be a desirable alternative to the Level 1 analysis, if the available data and resources are limited. However, the results of EKMA procedures are generally more difficult to verify as compared to Level 1 analysis.

Level 3 analysis is a simple technique for calculating the emissions reductions. However, this technique does not consider the effect of NO_x emissions on oxidant levels. The assumption used in the model, i.e., the maximum one-hour average oxidant concentration is a linear function of hydrocarbon emissions, has been criticized in many reports (4-6, 4-7, 4-8). This technique may be used for a first order approximation. Use of this technique for non-attainment planning and analysis may require EPA's approval in advance.

Strictly from the technical point of view, the Level 1 analysis is the most desirable approach to a non-attainment planning analysis. Level 2 can be considered as an acceptable alternative and level 3 analysis may be used only for preliminary assessment.

GENERAL GUIDELINES FOR TECHNICAL ANALYSIS

Several general guidelines for technical analysis are presented in this section. These guidelines, if followed, could help to facilitate future oxidant non-attainment analysis. These guidelines stem primarily from the experiences and lessons gained in preparing the 1979 oxidant non-attainment plan for the San Francisco Bay Region (4-9). Recommendations are presented for what to do and what not to do when selecting and conducting technical analyses. It is hoped that other non-attainment areas may extrapolate from the Bay Area's experience and gain useful insight into how to improve the technical analysis work in their non-attainment planning efforts.

As noted previously, the oxidant control analysis involves various kinds of uncertainties, assumptions, and simplifications. The techniques used are at best classified as "projection", "estimate", or "prediction". Such an analysis is frequently frustrated by the lack of data, guidelines, resources and experienced personnel. Tradeoffs between degree of accuracy desired and available resources have to be made at most steps of the analysis. Analyses and predictions, whether they be land use, emissions, or future oxidant levels, will not be completely defensible. Credibility of the technical analysis in an oxidant non-attainment planning effort is of importance as it usually leads to a costly and frequently controversial control program. The following basic considerations are suggested for improving future non-attainment analysis efforts.

- Emphasize the Initial Planning and Design of Technical Analysis

  A successful non-attainment planning effort requires a sound initial planning and well-organized management approach. Before initiating the actual technical analysis, the non-attainment lead agency must carefully define what objectives and requirements of the Clean Air Act the non-attainment plan has to meet. Then an appropriate level of analysis can be selected. The selection must be based on a systematic evaluation of a number of factors including:

  - magnitude of oxidant problem
  - level of sophistication and degree of accuracy desired
  - time schedule for the non-attainment planning
  - availability of data, budget, manpower, equipment and other resources
  - capability of staff

  Once the level of analysis (either Level 1 or Level 2) is selected, a sufficiently detailed project plan should be prepared. As a minimum, the project plan should cover:

  - specific analysis elements and tasks which must be completed
  - time schedule and interrelationship of those tasks
  - approximate manpower resources requirements for each task

  In addition to these technical analysis elements, the public and local government coordination should be initiated into the project plan along with a non-attainment plan review, revision, adoption and approval process. The initial planning effort should cover a sufficient level of detail to ensure the successful completion of the entire non-attainment analysis. The Guidance discussed throughout this document can be used in planning and design of a successful non-attainment planning program.

- Balance the Process and the Product

  Virtually all of the analysis elements, e.g., emission projection, oxidant prediction, etc. previously discussed contain some kind of process. Since it is difficult at best to verify the product (an emission inventory or an air quality projection for some future years), the most that can be expected is some general agreement that the analysis is as good as can be performed at the moment. The process by which the analysis is conducted is crucial to obtaining such an agreement. Conversely, as the number of individuals involved increases, staff resource requirements, review time, and coordination requirements multiply. It is therefore necessary to strike a balance between process and product according to the circumstances under which a particular analysis is being made.

- Keep All Analysis Elements Consistent

  As noted previously, outputs of one element (e.g., emission inventory) are usually to be used as inputs to a subsequent analysis element (e.g., oxidant projection). The consistency of all analysis elements must be maintained. A technically sound and defensible air quality projection is all but impossible without a technically sound and defensible emission projection. Similarly, the quality of an emission projection is largely affected by the quality of land use, economic, population and transportation projections. The allocation of resources to the analysis elements should be commensurate with the estimated significance of the element. For example, it is not prudent to spend 50 percent of the resources on 10 percent of the problem.

- Maintain Flexibility in the Choice of Methodology

  In an oxidant control analysis, techniques (especially projection techniques) and available data bases are still at a crude stage of development. Maintaining flexibility in the methodology used from one analysis to the next is important. Both methods and data bases, as well as the resources used to prepare the analysis, will change. The most appropriate methodology at any given time should be selected on the basis of conditions and constraints applicable to that time frame, rather than using one set of methodologies.

- Perform Sensitivity Analysis

  Projections, whether they be emissions or future oxidant levels, always have a number of inherent uncertainties, e.g., emission growth rate, meteorological conditions, etc. One way to deal with uncertainty is to conduct sensitivity analyses. Rough sensitivity analyses can be performed to determine whether the method(s) used is appropriate to the policy decisions being made. If significant uncertainty exists, the sensitivity of the decisions to such uncertainty should be examined. If the sensitivity is significant, then additional effort should be devoted to improving the methods and data bases used. (Several examples of sensitivity analyses are presented in Volume II of this Guidance.)

- Technical Analysis Should be Objective and Open

  Because a non-attainment planning program will be highly visible (due to public participation required by the Clean Air Act), objectivity is very important in all aspects of the work. Several methods can be used to maintain the professional integrity of the planning effort. An advisory committee may be established to provide early review and comment on the analysis. This group may meet on an as-needed basis for all the technical work, including technical assumptions, projection methodology, emission controls, etc. The comments received from this group should be incorporated into the work of the technical staffs. When agreement can not be reached on a particular assumption, it should be clearly stated and documented along with the rationale for each argument.

  Documentation of the key assumptions is also critical in projecting future land use, population, emissions and air quality. At a minimum, sufficient documentation should be provided for others to be able to reproduce the results. Where other reports are used, both the actual data and methodologies used should be cited. For the more complex analyses, sample calculations or interim data should be provided. As part of any non-attainment planning effort, time and money should be allocated in advance for providing reasonably detailed documentation of references, assumptions, projection methodologies, sources of data and the actual results.

- Be Consistent With Other Data

  Air pollution emissions and concentrations are directly related to urban activity in many forms. An air pollution emission-projection is generally based upon the projected levels of urban activities. In any given area where emission projections are being conducted, other projections are also being undertaken for population, employment, land use, transportation, water quality and supply, energy supply and demand, etc. To the extent possible, information from this other work should be used to ensure consistency of data from one program to another. A questionable assumption can always be debated and defended if it has been clearly documented. Very seldom, if ever, can inconsistencies (internal or external) in projections data be defended.

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Chapter 5

DETERMINING BASE YEAR OXIDANT CONCENTRATION

For ozone control planning and analysis, one of the initial tasks is to define the baseline ozone concentrations. The baseline ozone concentrations are to be used to assess compliance with the ozone standard; they also provide a basis for determining an appropriate design value for use in developing control strategies. In most non-attainment areas, baseyear ozone concentrations are determined based on ozone sampling data obtained at existing monitoring stations.

In February 1979, U.S. EPA promulgated a new ozone standard (5-1). The new standard is defined as "the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm must be less than or equal to 1". This differs from the previous standard for photochemical oxidants, which simply states a particular standard not to be exceeded more than once per year. As a result, the approaches to interpreting compliance with the ozone standard, and the procedures for determining an appropriate design value have also changed. The following two subsections briefly discuss the procedures for interpretation of the new ozone standard and for determination of a design value.

INTERPRETATION OF AIR QUALITY AND THE OZONE STANDARD

The key issue in interpreting air quality data and the ozone standard is to determine when the expected number of exceedances is equal to or less than 1. In the areas where sampling is complete, i.e., a valid daily maximum hourly average value is available for each day of the year, the procedure for determining the expected number of exceedances is straight forward. The expected number of exceedances at a monitoring site is determined by calculating the average of the number of exceedances recorded for each of the past 3 calendar years. Compliance with the standard is determined based on whether this average is less than or equal to 1.

In reality, a valid daily maximum 1-hour average ozone value may not be available for each day of the year. Incomplete sampling must be accounted for in determining expected number of exceedances. This can be done by using the following formula:

$$e = v + \frac{v}{n} \cdot (N - n - z)$$

Where

e = the estimated number of exceedances for the year
N = the number of required monitoring days in the year
n = the number of valid daily maxima
v = the number of daily values above 0.12 ppm, and
z = the number of days assumed to be less than the standard level.

More detailed information on the procedures for analyzing sampling data and computing the expected number of exceedances can be founded in References 5-1 and 5-2.

DETERMINATION OF DESIGN VALUE

Conceptually, the design value for a non-attainment area is the value that should be reduced sufficiently to ensure that the area will meet the standard. The design value is important in determining required emission controls and in developing control strategies, especially when EKMA (Level 2 analysis) or Rollback technique (level 3 analysis) is to be used. Under the previous photochemical oxidants standard, a design value is the second highest measured value. The promulgation of the new ozone standard has resulted in a revision to the definition of the design value. With the wording of the new standard, an appropriate design value is the concentration with expected number of exceedances equal to 1. In other words, the design value is chosen so that the probability of exceeding this concentration is 1 out of 365. Four alternative methodologies which may be used to estimate a design value are discussed in detail in Reference 5-2. They are: (1) fitting a statistical distribution method; (2) table look-up procedure; (3) graphical estimation; and (4) conditional probability approach. The first three methods group sampling data from several years into a single frequency distribution and estimate the design value at the frequency equal to 1/365. The last method treats sampling data from each year individually in determining a design value. For the uses, limitations and examples of these methods, the reader is referred to Reference 5-2.

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Chapter 6

EMISSION INVENTORY AND PROJECTIONS

In an oxidant non-attainment planning analysis, the emissions inventory and projections are used as the basis for predicting oxidant concentrations and subsequently for developing control strategies. Additionally, the emissions inventory and projections can be used to evaluate "reasonable further progress" toward attainment of the oxidant standard. A sound non-attainment plan relies heavily upon developing a detailed and objective emissions inventory.

As required by the Clean Air Act, an emissions inventory must be accurate, comprehensive, and current. The inventory is an accurate accounting and characterization of all emissions and their sources in the non-attainment area. To compile an inventory, the following information is needed: location of emission, type of process, type and quantity of emissions, type and efficiency of control system and stack/effluent parameters. Additionally, significant sources affecting non-attainment outside the non-attainment area need to be included. Because the emissions inventory for an oxidant control program should be as current as possible, a recent baseyear must be selected. Consistency with air quality data should also be considered in selecting a baseyear for the emissions inventory. To determine whether the oxidant standard is to be achieved in future years, emissions projections for those years need to be developed. These projections are based on assumptions for future emission source growth and development, technical developments, and various emission limitations. This chapter presents guiding principles for preparing the emission inventory and projections.

PLANNING FOR EMISSIONS INVENTORY/PROJECTIONS

Before compiling an emission inventory, some initial planning with a sufficient level of detail must be carried out in order to ensure successful completion of the project. During the planning, the objectives and specific needs of the emission inventory with respect to the oxidant control program must be defined first. Consistency among the oxidant analysis elements, e.g., urban activities projection and oxidant modeling, needs to be determined. Appropriate methodology is then developed to meet the objectives. Levels of detail, manpower, time, equipment and expertise requirements of each methodology must be evaluated against the availability of source data, resources, and other constraints. General Guidelines for planning the technical analysis have been discussed in Chapter 4. The considerations specifically related to emission inventory and projections are discussed in the following paragraphs.

As noted previously, one of the primary uses of an emission inventory is as input to an oxidant model that relates source emissions to ambient oxidant concentrations. The emission inventory must be designed so that the results can be interfaced with control strategy development activities. Before planning an emission inventory, the oxidant prediction relationship (OPR) to be used should be determined. Then an emission inventory with a similar level of detail can be designed. Three levels of OPR are discussed in Chapter 4. The level of detail for the emission inventory and projections required by these three levels of analysis are different. Table 6-1 summarizes the three levels of emission inventories corresponding to each level of analysis.

Table 6-1. Comparison of Three Different Levels of Emission Inventory

Level of Analysis	OPR Used	Details of Emission Inventory Required							
		Precursor Emissions Considered	Geographical Area	Spatial Resolution	Temporal Distribution	Consideration of Species and Reactivity Classification	Information on Individual Source	Use of Existing County Inventory (NEDS or EIS)	Requirement for Computer to Process Data
1	photochemical dispersion model	reactive volatile organic compounds, NO_x, CO, and sometimes SO_2 and particulates.	entire non-attainment area (significant sources affecting non-attainment outside the non-attainment area also considered)	grid cell level (1,2 or 5 Km grid cell)	hourly	VOC and NO_x species allocation are required	required	substantial modifications and disaggregation of existing county inventory are necessary	computer with large storage capacity is required
2	EKMA	reactive volatile organic compounds and NO_x	entire non-attainment area (significant sources affecting non-attainment outside the non-attainment area also considered)	county or county equivalent level	annual(or seasonal--summer months)	aggregated VOC emissions and NO_x	desired but not required	may be used directly or with minor modifications	not required but desirable
3	Rollback	reactive volatile organic compounds	entire non-attainment area	county or county-equivalent level	annual (or seasonal--summer months)	aggregated VOC emissions	desired but not required	may be used directly or with minor modifications	not required

As can be seen, the Level 3 analysis (rollback method) requires an aggregated, annual HC emissions inventory for the baseyear. The Level 2 analysis (EKMA) requires an emission inventory with a degree of detail similar to that of Level 3; the only difference is that a NOx emission inventory is also required by the Level 2 analysis. In the Level 2 analysis, the relative temporal (post 8 a.m. period) and spatial distribution patterns of HC and NO_x emissions for the selected simulation day are needed if the city-specific (instead of standard) EKMA is to be used. In both Levels 2 and 3, the emission inventory can be compiled at county or county-equivalent levels and then aggregated for the entire non-attainment area.

The Level 1 analysis (photochemical dispersion model) requires a much more detailed emission inventory for HC, NO_x and other pollutants. A disaggregated emission inventory with spatial and temporal details, i.e., hourly emissions for each grid cell (1, 2, or 5 km) level, is required by photochemical dispersion models. Additionally, organic emissions must be broken down by species classes; ground-level and elevated emissions can also be treated separately. For this level of analysis, a significant portion of the effort will be expended on the preparation of the emission inventories.

Based on the above discussions, an emission inventory can be broadly grouped into two categories--aggregated and disaggregated. An aggregated emission inventory can be used in the Level 3 (rollback model) and Level 2 (EKMA) analyses. The disaggregated (spatially and temporally distributed) emission inventory is used for Level 1 (photochemical dispersion model) analysis. The basic differences between the aggregated and disaggregated emission inventory and projections are already summarized in Table 6-1. The information provided can be used for planning and designing the various levels of emission inventory required for the desired level of analysis in order to meet the oxidant control objectives.

OVERVIEW OF EMISSION INVENTORY AND PROJECTIONS PROCESS

To gain a perspective of the overall emission inventory and projections process, Figures 6-1 and 6-2 present block diagrams for the tasks involved in preparing the aggregated and disaggregated emission inventory and projections.

The process for compiling an aggregated emission inventory and projections begins with planning and design of the work tasks. A review and evaluation of existing emission inventories is the next task to be conducted. The guiding principle for this task is to utilize the existing emissions data and inventories to the fullest extent possible. Various techniques can then be used to collect missing data such as activity levels, process and operating variables of major sources, etc. Once the data collection phase is completed, the collected data are analyzed and compiled, and emissions are calculated. The baseyear emissions inventory is then established. The next step is to project the baseyear emission inventory to future years. Both the annual emissions inventory and projections are made at the county or county-equivalent levels, and then summed together for the entire non-attainment area.

Compared to an aggregated emissions inventory, a disaggregated emissions inventory involves many more tasks and a much greater level of effort. After completing the initial planning and evaluation of

Figure 6-1 **Block Diagram for Aggregated Emission Inventory/Projection Procedures**

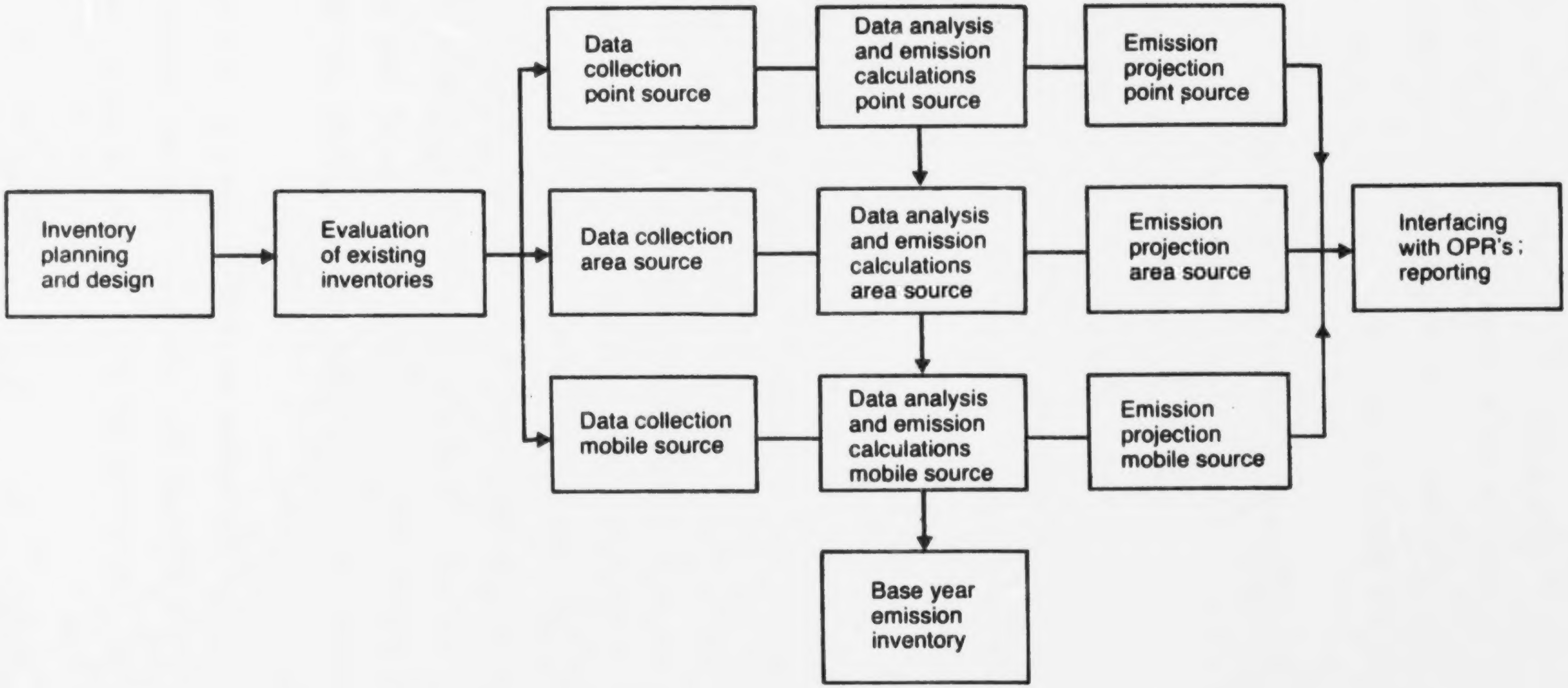
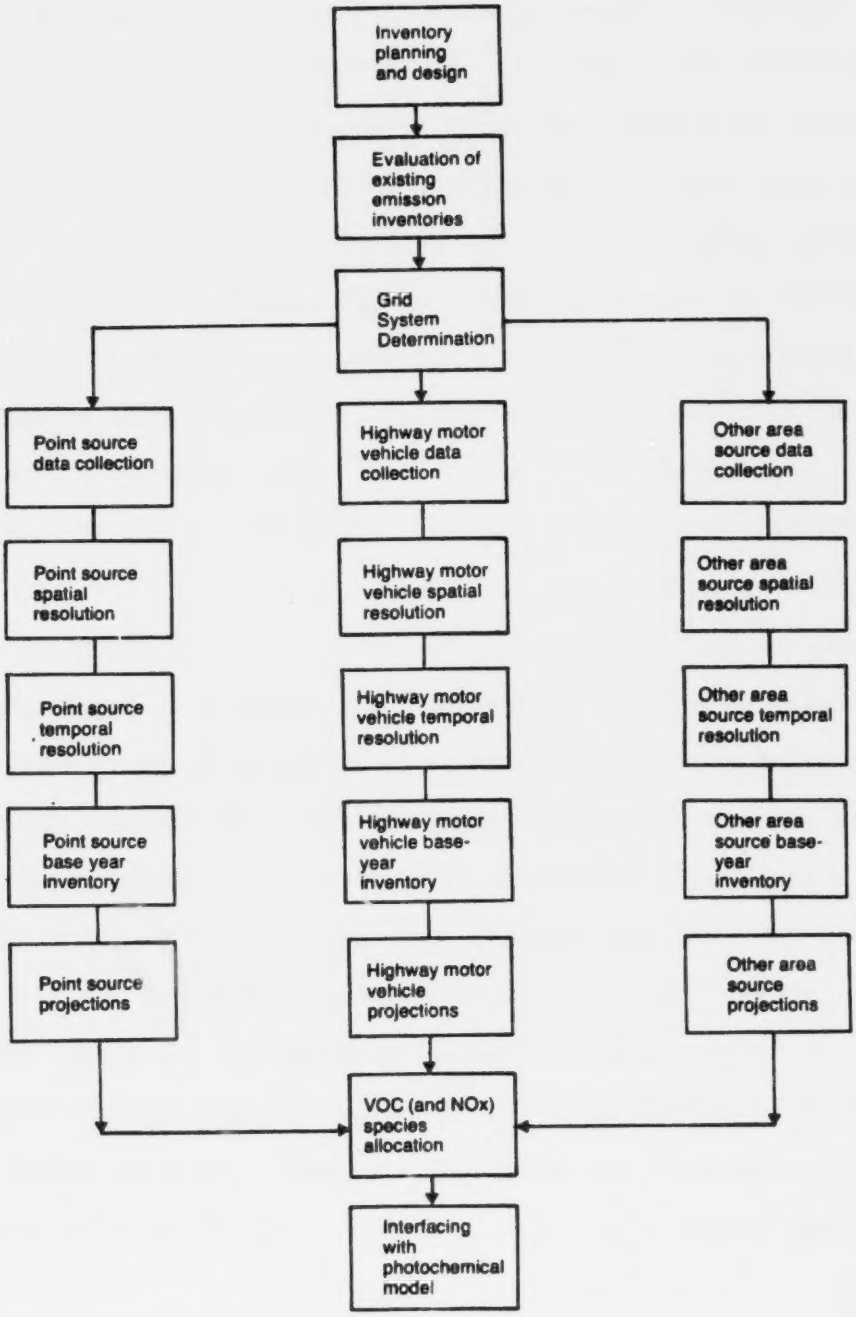

Inventory planning and design
Evaluation of existing inventories
Data collection point source
Data collection area source
Data collection mobile source
Data analysis and emission calculations point source
Data analysis and emission calculations area source
Data analysis and emission calculations mobile source
Base year emission inventory
Emission projection point source
Emission projection area source
Emission projection mobile source
Interfacing with OPR's ; reporting

Figure 6-2 **Block Diagram for Disaggregated Emission Inventory/Projection Procedures**


Inventory planning and design
Evaluation of existing emission inventories
Grid System Determination
Point source data collection
Point source spatial resolution
Point source temporal resolution
Point source base year inventory
Point source projections
Highway motor vehicle data collection
Highway motor vehicle spatial resolution
Highway motor vehicle temporal resolution
Highway motor vehicle base-year inventory
Highway motor vehicle projections
Other area source data collection
Other area source spatial resolution
Other area source temporal resolution
Other area source base-year inventory
Other area source projections
VOC (and NOx) species allocation
Interfacing with photochemical model

existing emission inventories, a grid system upon which the emission inventory will be based is determined. The next step is to collect data on urban activity levels, major point source operation, and others. Then, substantial amounts of effort are required to translate the data into emissions and to spatially and temporally distribute the emissions. From this the baseyear emissions inventory is established. A similar process using areal and source growth projections, legal requirements and technological advancements is then used to prepare the emissions projections for the future years. Another major task in the preparation of disaggregated inventories is the splitting of the HC and NOx emissions into the various species classes required by the photochemical model. This effort requires the expertise of an organic chemist and detailed knowledge of the model's photochemistry and the region's emission inventories.

Some of the tasks, e.g., "Evaluation of Existing Emission Inventories" and "Data Collection", are common to both aggregated and disaggregated inventories. In these cases, the data and information as well as level of detail required by the same tasks are more substantial in the disaggregated inventories than for the aggregated inventories. However, the techniques employed to carry out the tasks may be similar. For this reason, the guiding principles for those tasks common to both levels of inventory compilation are discussed jointly in the following task description sections. Tasks unique to each type of inventory (either aggregated or disaggregated) are noted. The planning and design of emission inventory and projections have been addressed in previous sections.

EVALUATION OF EXISTING EMISSION INVENTORIES

Following completion of all preliminary tasks, a review and evaluation of the existing emission inventories should be made. In most non-attainment areas, a conventional annual, countywide emission inventory, i.e., EPA's NEDS and/or EIS (6-1, 6-2, 6-3) already exists. Additional permit and compliance related emissions data are also maintained by local air pollution control agencies. More importantly, an inventory for oxidant precursor emissions has been prepared and is generally available in most designated non-attainment areas. Many of these data may be used directly in the oxidant control program. In many cases, the existing inventories can be updated or upgraded through limited contact with the sources or through the use of an abbreviated questionnaire. Attempts should also be made to identify the data collection, data processing systems, and other framework already established for the inventory. Thus, if the existing inventory does not meet the current needs, data collection and updating procedures can be built upon the existing framework. In principle, an emission inventory should make use of the existing data and system to the fullest extent possible.

The following considerations are suggested for the evaluation of any existing emission inventory:

- Representative of current conditions - is the existing inventory current or out-of-date?
- An accurate accounting of all appropriate sources - as most existing inventories were not originally prepared for oxidant control programs, there may be a number of major organic and NO_x emitters that may either be omitted from the inventory or treated collectively as area sources because their emissions of some other pollutants are small; look for any obvious errors or omissions of large point sources.

- Consistency with the needs of the non-attainment plan - level of detail of the inventory should be consistent with the OPR to be used. In general, the existing NEDS or EIS may be suitable for Level 2 (EKMA) and Level 3 (Rollback) analyses. Substantial modification and disaggregation of existing NEDS and/or EIS are required if the Level 1 analysis (involving a grid-based photochemical model) is to be used.
- Consistency in institutional boundaries - most existing emission inventories are at county levels. If a county is not entirely located within the non-attainment area, extra effort is needed to apportion that county's total emissions to the non-attainment area.

DETERMINATION OF THE GRID SYSTEM

This task is needed only when a grid-based photochemical dispersion model is used as a primary tool in oxidant control analysis (see Figure 6-2). A grid-based photochemical model requires distribution of total emissions to the grid cell level. Therefore, developing an appropriate grid system at the start of the emission inventory effort is important. Generally, rectangular grid cells of equal size are chosen. Selection of the cell size and the overall grid system is affected by the resources available for the detailed emission inventory and the computer model to be used. More detailed guidelines can be found in references 6-4 and 6-5.

DATA COLLECTION

As shown in Figures 6-1 and 6-2, data for emission estimates are generally collected and compiled in three separate categories: point source, area source, and mobile source. This is because the methodology for preparing emission estimates and the required data are different for each category. For each of the three categories, there are several techniques which can be used to obtain the necessary data. In general, the necessary data for large and small point sources are the process and operating variables, and test emissions data if available. For mobile and area sources, activity levels and emission factors are needed. Selection of particular techniques or combination of techniques must be based on the guiding principles discussed previously (objectives, level of accuracy and detail desired, consistency with the requirements of OPR, overall time schedule, resources available, etc.). The most commonly used data collection techniques are summarized in Table 6-2. The mail survey approach and plant inspection are most useful for gathering data from point sources. Field surveys and review of published data sources are useful for collecting area source information. The urban systems modeling is a primary tool for estimating the size and distribution of urban activities. It is the best way to produce the detailed urban activity data necessary for spatial and temporal distribution of emissions. A number of references for urban systems modeling is given in Appendix A. Table 6-2 also briefly describes the advantages and disadvantages of each technique. The "how to" procedures for these techniques can be found in References 6-6 and 6-7.

DATA ANALYSIS AND EMISSIONS CALCULATIONS

Once the necessary data have been obtained, they must be interpreted, compiled and entered into the data base. With these data, various methods can be used to estimate emissions for area and mobile sources. The "emission factors method" is most commonly used. An emission factor for a particular source is defined as the amount of

TABLE 6-2

COMPARISON OF VARIOUS DATA COLLECTION TECHNIQUES
FOR BASEYEAR EMISSION INVENTORY

Technique	Characteristics
Mail Survey Approach (Questionnaire)	• Most common technique for collecting point source data. • Also useful for collecting small point sources to be reported collectively as area source. • Response of questionnaire varies. • Errors may result from interpretation of questionnaire, or from incomplete questionnaire.
Plant Inspection	• Provide most complete and accurate information. • Resource-intensive; usually performed only at important or unique large point sources.
Field Surveys	• A primary tool for directly gathering information on certain area sources, such as agricultural burning. • Errors may result from extrapolating the survey results to the entire area. • Costly method; used only when it is absolutely necessary.
Published Data Source	• Primary tool for obtaining activity level information on most area sources. • Supplemental method for gathering point source data if a questionnaire is not returned. • Published data are generally not as current as required.
Urban Systems Modeling	• Primary tool for estimating size and distribution of urban activities. • Best way to produce urban activity data necessary for spatial and temporal distribution of area source emissions. • Resource-intensive; only experienced staff can perform the modeling.

pollutant released to the air from that source divided by the activity level of that source; for example, grams of hydrocarbons per vehicle mile traveled. The emission factor method calculates the total emissions simply by applying a representative activity level to an emission factor. EPA has published numerous techniques for estimating emissions for many pollutant sources, e.g., AP-42 and its Supplements.

For point sources, attempts should be made to collect emissions data directly from the owners (see previous section on Data Collection). If they are not collected or not available, the "source test" method or "material balance method" may be used to determine the emissions. The source test method monitors the source to determine the actual emissions. The material balance method calculates emissions by analyzing the material composition and balance for a process. It should be noted that the emission factor method is also frequently used for estimating point source emissions.

Table 6-3 compares the above-mentioned three emission estimation methods in terms of their application, resource requirements and limitations. More detailed information on the procedures can be found in references 6-6 and 6-7.

SPATIAL RESOLUTION OF EMISSIONS

If a grid-based photochemical dispersion model(s) is to be used in an oxidant control program, emissions data must be resolved to the grid cell level. The effort needed to spatially resolve emissions data varies, depending on the type of emissions involved. For point sources, it is easy to assign the emissions to the appropriate grid cell as one can pinpoint their locations with a street map and a USGS map of the

TABLE 6-3

COMPARISON OF EMISSION ESTIMATE METHODS

Method	Characteristics
Source Test	• Most accurate but resource-intensive method. • Particularly useful for quantifying major point sources; also useful for developing emission factors for area sources. • Statistical validity of testing results greatly affected by the number of tests, time period and duration of testing, and other factors.
Material Balance	• Useful method to determine certain types of large and small sources, e.g., evaporative, low level, intermittent or fugitive organic emissions, for which source testing method cannot be used. • Needs detailed process and operational information; only experienced engineers can do the calculations.
Emission Factors	• Most commonly used method for area sources. EPA AP-42 has developed emission factors for most pollutant sources. • Most suitable for estimating mobile source emissions, petroleum storage and handling emissions, and other area sources.

same scale.

For area sources, spatial distribution of emissions may require substantial effort. In most cases, area source emissions are reported at county or county-equivalent levels. Various alternatives may be used in distributing the countywide emissions to the grid cell level (6-4, 6-5). Table 6-4 compares four commonly-used techniques for spatially distributing area source emissions. Reference 6-4 has detailed discussions on spatial resolution of various types of area source emissions (petroleum storage and marketing, solvent evaporation, residential fuel combustion, etc). More information on spatial distribution of emissions may be found in Reference 6-5.

Mobile source emissions represent a challenge for spatial resolution. In conventional countywide emission inventories, mobile source emission estimates are usually based on countywide gasoline sales or total VMT. This kind of inventory does not provide the information necessary for spatial distribution. Since mobile sources generally represent a large fraction of total organic emissions, a more detailed procedure is needed to estimate and distribute mobile source emissions. Procedures for estimating and distributing mobile source emissions generally include:

- obtaining detailed traffic data from transportation planning agencies (link-by-link VMT, trip generation data, etc.), or by using travel demand forecasting models (see Appendix A),
- allocating link-by-link VMT and trip generation data to the grid cell level, and
- estimating emissions at a grid cell level using EPA's methodology for calculating mobile source emission factors.

TABLE 6-4

ALTERNATIVE METHODS FOR SPATIAL DISTRIBUTION OF AREA SOURCE EMISSIONS

Method	Characteristics
1. Uniform distribution of emissions.	• This is the simplest method, and might be accepted for fairly uniform residential or agricultural area. • Cannot be used in areas with diverse land uses.
2. Distribution of emissions as a function of population.	• Useful technique to distribute residential areas' emissions. • Most census data concerns residential population only, and would thus displace many non-major point sources which operate in industrial and commercial areas. • Spatial detail may be limited by census tract size, especially in sparsely populated areas.
3. Distribution of emissions as a function of surrogate indicators.	• Most commonly used technique; a great improvement over methods 1 and 2.* • Require information on population, land uses, employment and others; a resource-intensive method.
4. Emission inventory directly for each grid cell.	• Most accurate method. • Most resource-intensive; computer is required.

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*Used in the non-attainment planning in the Bay Area. Details are discussed in Volume II of this Guidance.

Allocation of link-by-link VMT and trip generation data to the grid cell level is usually a simple matter. It can be done by using a network map and a same scale USGS map and then determining the UTM coordinates for each segment of traffic network and each traffic zone. More detailed discussions on spatial resolution of mobile sources can be found in References 6-4 and 6-5.

Errors in spatial distribution do not change the total mass of pollutant emissions. In this case, a photochemical dispersion model is intended for regional photochemical modeling (as opposed to local plume modeling) so small distribution errors should not be critical to the oxidant analysis result.

TEMPORAL RESOLUTION OF EMISSIONS

In order to be used in photochemical dispersion modeling, emissions must be resolved to the hourly level. For major point sources, the hourly and seasonal process variations are generally known. This temporal resolution of point source emissions constitutes no problem. For mobile source and other area sources, the most accurate and most resource-intensive approach is to determine the emissions of each individual source for each hour of the time period being modeled. A less resource-intensive and more commonly used approach is to develop typical hourly patterns of activity levels for each source category, and then to apply these hourly factors to annual or daily emissions to estimate hourly emissions. In developing hourly factors, considerations should be given to seasonal, weekend/weekday, and peak and average condition variations. The factors important to temporal resolution of point, area, and mobile sources are discussed in detail in Reference 6-4.

EMISSIONS (HC AND NO_x) SPECIES ALLOCATION

Since a photochemical dispersion model simulates the process of photochemistry, precursor emissions must be distributed into the various species classes required by the model. Generally speaking, hydrocarbon (HC) emissions are divided into several species classes that behave similarly in photochemical reactions. One classification scheme groups HC into four classes: paraffins, olefins, aromatics and aldehydes; another scheme divides HC by the number of certain types of carbon bonds present in each HC molecule. Some models also require breakdown of NO_x into NO and NO_2. Actual species classification required by various photochemical models can be found in Reference 6-4.

The HC and NO_x species allocation scheme used in the photochemical model must be known before compiling an emission inventory because the classification scheme influences the information requirements for each source category and thus the data handling process. If the emissions data collected are not broken down into species classes, assumptions about HC and NO_x species distribution must be made for each source category in order to allocate emissions to various species classes. Techniques for HC and NO_x species allocation are discussed in detail in Reference 6-4.

EMISSIONS PROJECTIONS

Emissions projections include not only forecasting changes in activity levels, but also involve estimating the effects of emission control regulations to be implemented. Estimates of changes in activity levels are usually based on projections of land use, population, housing, employment and travel demands. These forecasts are generally made by regional, local and/or state planning agencies (see Appendix A.) Additionally, construction of new sources, expansion of existing facilities, closing of old plants and other similar information on individual sources must also be included.

Estimating the effect of emission control regulations is also a complicated task. It requires an evaluation of the effect of the promulgated "reasonable available control technologies", compliance schedules, new source emission standards and change in emission factors.

There are two types of emissions projections: baseline emission projections and control strategy emissions projections. Baseline emissions projections are prepared by considering the projected changes in activity levels and the effects of control regulations already scheduled or in effect. Baseline emissions projections serve as a basis for determining the emissions reductions necessary to attain the oxidant standard.

Control strategy emissions projections are emissions estimates which incorporate the effects of new, changed, and/or additional control strategies not included in the baseline projection. Control strategy emissions projections are used as inputs to a photochemical dispersion model to predict the ambient oxidant concentrations resulting from the proposed control strategies.

Problems

Emissions projections, by their very nature, are speculative and represent nothing more than a "best guess" of future conditions. They frequently involve a number of assumptions, judgments, and other similar uncertainties. There are generally inherent problems in any emission projections. These may include the following (6-8):

Defensibility - Projections, whether they be population, unemployment, or emissions, will always be attacked because of their speculative nature. The technical credibility of emissions projections will be a function of their reasonableness (i.e., is it plausible), the amount of research and documentation of assumptions, and the procedures or methodologies used to make the projections. In the final analysis, no projections are completely defensible; however, there is no reason why they should not be clearly documented, reasonable and technically credible.

Objectivity - Because of the importance emission inventory projections play in urban activity planning--e.g., industrial siting decisions, air quality control strategies, highway and sewage treatment construction programs--the motives of projecting emission inventories are always questioned. Depending on the perspective being pursued the forecast emissions are "too high,", "too low," "surprisingly conservative," or "unduly optimistic". It is not uncommon for a particular set of projections to be all of the above at the same time! Projections will be perceived very differently depending on the eye of the beholder and what must be strived for is technical objectivity in the process.

Openness - Because of the previous two problems--defensibility and objectivity--openness and candor in making emission projections is needed to gain any credibility. Many a projection has been made by junior staff in a "closet" which upon closer examination was not documented, and thus seemingly arbitrary, or which though documented was clearly unsupportable. Internal and external review of emission inventory projections will almost always improve their technical quality and enhance their credibility.

Uncertainty - Simply stated, projecting emission inventories is fraught with uncertainty. Some uncertainty can be accommodated by projecting in ranges or conducting sensitivity analyses with different assumptions. However, some degree of uncertainty will always accompany emission projections. This fact should always be acknowledged immediately. The art of projecting emission inventories is not eliminating uncertainty, but learning how to minimize it.

Consistency - Emission inventories are seldom compiled in a vacuum. In any given area where emission inventories are being projected, other projections are also being undertaken for population, employment, land use, transportation, water quality and supply, energy supply and demand, etc. To the extent possible, information from this other work should be used to ensure consistency of data from one program to another. A questionable assumption can always be debated and defended if it has been clearly documented. Very seldom, if ever, can inconsistencies (internal or external) of projections data be defended.

Resources - Very substantial amounts of time and money can be spent on emission inventory projections. Generally though, since neither a lot of time or money are available, common sense should dictate the resources to be allocated to this task. Seldom are too many resources devoted to this assignment (if anything the converse is true). As a rule of thumb, sufficient resources should be committed to conducting emission inventory projections to circumvent many of the problems cited above. Also, the allocation of resources should be commensurate with the estimated significance of a particular source category. For example, it is not prudent to spend 50 percent of the resources on 10 percent of the problem.

Guiding Principles

The general guidelines for technical analysis discussed in Chapter 4, if kept in mind, will help to minimize the above-mentioned problems. Additionally, the following guidance is also important to improving emission projections.

- Methodology consistent with that used in baseyear emissions inventory - it is essential to project emissions based on methodology and computation principles consistent with those used in the emission inventory for the baseyear. This procedure, which should be applied to each emission category, will insure consistency between baseyear emissions inventory and the future year emission projections. For example, if a predictive land use model (PLUM) is used to estimate land use activity levels in the baseyear, the same model should be used to project future land use activity levels. Otherwise, spurious emission differences may result from changes in methodology and the associated assumptions.

- Close coordination with planning agencies - as noted previously, forecasts of future urban activities (land use, population, employment, transportation, etc.) are generally conducted by agencies other than air pollution control agencies. The benefits of close coordination with planning agencies are two-fold: 1) consistency with other planning programs - in a non-attainment area where emission projections are being made, there are probably several other projections also being undertaken for land use, population, employment, etc. Emission projections should be based on the information from this other work, thus, the consistency of data from the oxidant control programs to others can be established; and 2) optimizing the usefulness of planning data already developed for the non-attainment area - this may substantially reduce the effort required for emission projections.

Overview of Projection Approaches

There is no one correct way of projecting emissions. Many factors influence the procedures to be used. These factors include availability of data and resources, personnel, and level of sophistication or degree of detail required. Since so many air pollution emission source categories exist, it is prudent to be cognizant of as many projection techniques available as possible so that different procedures can be used as appropriate and as differing circumstances dictate.

Perhaps the simplest and most frequently used technique is linear extrapolation or regression where a series of historical data points are projected into the future in some simple linear fashion. This procedure has obvious advantages and disadvantages which will not be articulated here. A more rigorous extension of the linear regression techniques is the time series multiple regression procedure. Here the historical emission estimates are correlated to any number of independent variables (e.g., population, automobiles, income, fuel use). What results is an equation which represents the "best" correlation of the independent variables with emissions for use in projecting future emissions. The theory of this technique is that the historical factors which have apparently accounted for emissions will continue to do so in the future in the same manner. To accurately forecast emissions using this technique requires an accurate forecast of all the independent variables assumed to be important in accounting for historical emission trends.

Frequently, very little data are available to assist in making future projections. In these cases, engineering or scientific judgment must be used. This can be done in one step in what amounts to be a "best guess" or in more systematic group techniques such as the Delphi method. Other gaming procedures are also possible.

Another emission projection methodology is the use of surrogate variables. This procedure assumes that a given pollution source category can be accurately projected by projecting some related variable. For example, increases in aircraft emissions might be based on projected increases in passenger air travel. Similarly, hydrocarbon emissions from service stations might be projected on the basis of forecasts of gasoline sales.

The EPA and other agencies have published several reports and guidelines addressing emission projections. Detailed "how to" procedures for the above-mentioned approaches can be found in References 6-7, 6-9, 6-10 and 6-11. The surrogate indicators methodology, used in the oxidant planning program in the San Francisco Bay Area, is detailed in Volume II of this Guidance. Selection of particular techniques or a combination of techniques should be based on the guiding principles discussed above.

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Chapter 7

OXIDANT PREDICTION METHODS

Three levels of sophistication in oxidant prediction methods are presented in this guidance. The most sophisticated is the Level 1 analysis. At this level of analysis, a dynamic grid-based photochemical model or a trajectory model may be used for predicting oxidant levels resulting from proposed emission control strategies of oxidant precursors. The Empirical-Kinetic Modeling Approach, EKMA, is the Level 2 analysis. A standard set of ozone isopleths can be used in the EKMA procedure to assess emission control strategies. Another option of EKMA is to use a trajectory photochemical model, i.e., the Ozone Isopleth Plotting Package (OZIPP), to simulate maximum 1-hour average ozone concentrations. The results of OZIPP simulations are used to generate an ozone isopleth diagram. This diagram is then used in the EKMA procedure to calculate the required ozone controls. Last is the rollback technique (i.e., Level 3 analysis). The rollback model is based on the assumption that for a given region, a reduction in hydrocarbon emissions will produce a proportional reduction in maximum oxidant levels. This chapter discusses these three levels of analysis.

LEVEL 1 - PHOTOCHEMICAL DISPERSION MODELS: GRID OR TRAJECTORY MODELS

General Description

Photochemical dispersion models attempt to describe in mathematical terms the various physical and chemical processes that are responsible for ozone formation. They can be used to quantify the relationships between emission sources and ozone concentrations at various receptor locations, and similarly to evaluate the effectiveness of proposed emission control strategies on oxidant precursors. At this level of analysis, a grid (Eulerian) or a trajectory (Lagrangian) model may be used. The following paragraphs briefly discuss these two types of models. For more detailed information on application of photochemical dispersion models, the reader is referred to Reference 7-1.

A grid-based photochemical dispersion model simulates ozone formation and transportation on a grid over the region of interest by considering diffusion and chemical reactions of oxidant precursors as they are passed from grid to grid according to the wind field defined for each grid. The atmospheric diffusion of pollutants is treated in three or two spatial dimensions. Among various photochemical models, the grid-based models are the most sophisticated and offer the highest accuracy of ozone prediction. However, the level of effort required is the greatest and the data and resources needed are the most extensive.

A trajectory model may be a compromised alternative to a grid-based model if available data and resources are relatively limited. A trajectory model considers oxidant precursors as they enter into a air parcel moving along a trajectory path according to local mean wind speed and direction. Ozone formation and transportation is simulated by solving equations of chemical reactions and vertical mixing of pollutants in the air parcel.

The following is a list of example photochemical dispersion models available:

Grid or Eulerian models -

- LIRAQ-2, developed by Lawrence Livermore Laboratory. This was the model used for the San Francisco Bay Area non-attainment analysis (7-2)*.

- SAI Urban Airshed Model, developed by Systems Applications, Inc. The model has been used for several urban studies (7-3)*.
- IMPACT, developed by Science Applications, Inc. The model was developed for the CARB (7-4)*.
- MADCAP, developed by Form and Substance, Inc. San Diego is using this model for its non-attainment planning analysis (7-5)*.

Trajectory or Lagrangian models -

- ELSTAR, developed by Environmental Research and Technology, Inc. This model was developed for the Coordinating Research Council (7-6, 7-7)*; an official document is to be published in the near future.
- OZIPP, developed by the U.S. EPA. This model is usually used along with EKMA and will be discussed in the Level 2 analysis of this guidance (7-8)*.

Because of their sophistication, photochemical dispersion models have the highest potential for answering a number of strategic oxidant control issues. These issues would be of importance in evaluating the effectiveness of alternative emission control strategies in reducing ambient oxidant levels. Among these issues are the following:

- Hydrocarbon versus NC_x control - These pollutants are the primary ingredients in the photochemical reaction for ozone formation, and changes in the hydrocarbon/NOx ratio due to various emission control strategies would change the resultant oxidant concentration. Eulerian or Lagrangian models can be used to provide estimates of the degree of both hydrocarbon and NO_x control required to meet the standard.
- Assessing attainment of oxidant versus short-term NO_2 standard - A short term NO_2 standard is called for in the 1977 Clean Air Act Amendments. Eulerian and Lagrangian models can theoretically perform both oxidant and NO_2 predictions. The validity of the latter prediction still needs to be field-verified.

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*References cited are the user's manual(s) for the model.

- Control of low-level vs. elevated sources - This issue weighs the cost-benefit ratio of one type of source control policy vs. another. Vertical resolution is needed to address this issue. All but the LIRAQ-2 models are multi-layer models in the vertical and can be used for such a policy evaluation.

- Selective control of hydrocarbon compounds - It is possible that in the preparation of alternative emission control strategies, sources emitting a single hydrocarbon class might be singled out for control. The effect of such a policy on ambient ozone levels can be assessed by the complex models to a degree. The number of hydrocarbon classes ranges from three to five and these specific hydrocarbons can be used for control strategy testing.

- Long-range transport - Oxidants and its precursors are known to be capable of long-range atmospheric transport from one air region to another. In such an instance, the boundary and initial concentrations of the air region into which the pollutants are carried would reflect this effect as would the ambient oxidant levels. The magnitude of such an effect has not yet been assessed.

- Effect of spatial and temporal variation - Selective siting and defined operating schedules for projected sources would affect ambient oxidant levels. As the photochemical dispersion models are space and time dependent, they are most suited for such a growth policy study.

Input Data Requirement

Input data for a photochemical dispersion model can be broken down into three categories: 1) emissions, 2) meteorology, and 3) initial and boundary ozone and precursors levels (see Figure 4-1). For a grid model, these data need to be spatially and temporally distributed over a grid over the region. In other words, data are needed for each of the grid cells in the region. Efforts required for preparing such detailed inputs could be substantial. However, it should be pointed out that it is not necessary to observe all of the required data directly. Reasonable compromises can be made; such compromises were made with LIRAQ as described in Chapter 5 of the Volume II of this guidance.

Additionally, each of the above-mentioned grid models has preprocessor programs for manipulating raw input data into computer readable codes. This would minimize computation time and data preparation effort. Most grid models have preprocessor routines for each of the three input data categories. These are described below:

- Emissions: A complete, chemically disaggregated, spatially and temporally varying emission inventory must be developed for the study area. The amount of disaggregation necessary is dependent on the specific model. At the least, the hydrocarbon sources must be divided into those classes used in the photochemical simulation. NO_x emissions need to be divided among NO and NO_2.

  Because the models are space dependent, the emission sources must be located to the resolution of the grid except for point sources. These are specifically located at a grid point. For those models incorporating multi-vertical layers, a vertical resolution of the point source is also required. This is accomplished via plume rise calculations so that the stack and plume design conditions are required input.

  The temporal variation of each emission source must be stated. Usually, a one hour resolution is adequate.

  Area and mobile sources can be defined on the grid by a complex urban system model and a detailed traffic demand and network model.

  The labor requirement to produce this inventory is dependent on the existing data. However, most air quality regions either do not have a complete inventory and/or it is in the wrong format. Several man-months are normally required.

- Meteorology: A mass consistent wind field is used by all the models for pollutant transport. All the models except LIRAQ-2 use a three dimensional field. LIRAQ is single layered. Input to generate the wind field are wind direction and speed at different heights (except for LIRAQ which requires only surface measurements); wind shear between layers; inversion height; insolation; topography; latitude and longitude and date. Except for the last three inputs, all the data needed to generate the wind field should ideally be available for each grid. This not being the case usually, interpolation between sites of actual measured data must be carried out. Because of the lack of data and interpolation, the resultant field must be scrutinized by an experienced meteorologist to appraise its consistency, especially in complex terrain. This process needs to be repeated for each simulation day as they are selected. This is nontrivial task in itself, requiring several person-days per simulation day.

- Initial and boundary ozone and precursor levels: These specify the concentration of ozone and precursors at the edge of the study area and at the start of the model simulation for each grid. Most of the time, little or no actual data are available and professional judgment is applied.

Generally, the types of input data required for a trajectory model are similar to those for a grid model, but the level of detail may be less. Theoretically, a trajectory model requires input data only for the corridor encompassing the trajectory path. However, general application of a trajectory model to a non-attainment area usually requires that emissions and meteorological data be assembled for a significant portion of the non-attainment area.

The most advanced trajectory model, i.e., ELSTAR, requires input data with a level of detail almost identical to that required for a grid model. The ELSTAR requires the following inputs:

- Area Source Emissions
- Point Source Emissions
- Diffusivity Coefficients and Spatial Mesh
- Initial Concentrations of Species
- Latitude, Longitude, and Date

The area and point source emissions including NO_x, CO, and five separate classes of hydrocarbons must be prepared as a function of time (e.g., hourly). The emissions data are created by an emissions source flux generation program. This preprocessor program requires a gridded emission inventory to compute schedule fluxes for a specified trajectory. The fluxes are computed by summing up all of the emissions from all sources types in the inventory that exist in a given grid cell at a given time.

The data measured at meteorological stations (surface wind speed, surface temperature data and radiosonde data) are required by another preprocessor program to determine the diffusivity coefficients. The output from the program also supplies information necessary to the user to specify mesh geometry. The last two items of the required inputs can be readily obtained or estimated from existing sources.

Model Validation

Because a photochemical dispersion model attempts to duplicate a real world situation mathematically, its predictions should be verified by comparison with observed data. If all the input data were correct and the input assumptions were within reason, the modeling results should parallel the measured data. If possible, input information may be adjusted within their range of uncertainty to see if agreement is improved.

A model which is sufficiently complex to simulate chemical-physical processes should not have to be calibrated. There are two options for dealing with the problem of imperfect model performance. The first option is to accept the model results as they are, making no attempt to "correct" or "calibrate" the results according to observed data. This may be done with confidence if more than one prototype day is used during the model evaluation and validation process to eliminate any systematic bias in model results. However, it may not always be possible to eliminate all systematic bias or to obtain satisfactory results for several different prototype days, particularly if schedules are constrained by regulatory deadlines. In such cases, some method should be considered for appropriately compensating the results to ensure that control requirements are not either understated or overstated. Issues relating to model validation or calibration need further investigation.

Baseline Oxidant Predictions and Development of Alternative Emission Control Strategies

The baseline oxidant prediction is defined as the oxidant level for some future year if only current regulations for emission control were applied. Calculation of this baseline prediction involves developing a future emission inventory based on regional growth and development policies; regional transportation plans and policies; and regional stationary source development. The meteorological scenarios for the simulation days are used. Boundary and initial conditions used for the simulation day can be used or others can be input. Once the baseline oxidant predictions are made, various emission control strategies can be applied to the future year inventory and the effect on oxidant formation can be discerned. However, because of the large computational costs of running these models, the labor requirements to develop the emission inventory and to interpret the output, the number of control strategies should not be excessive. A prior screening is advisable.

Sensitivity Analysis

The model predictions should be used with discretion because the results are only as good as the input. Many assumptions and simplifications have gone into the model formulation and input due to inadequate knowledge of certain actual phenomena, limited computer capability and lack of good data.

The initial and boundary levels are an important assumption, especially in a short (e.g., 12 hours) simulation. The time required to derive input values from the simulation is equal to or greater than the time needed to perform the short simulation.

Some sensitivity studies have been performed on these models. A common one is the effect of varying precursor levels on oxidant formation, which is another way of looking at emission control strategies. LIRAQ has been used in San Francisco for such a study. SAI AIRSHED addressed this in the Denver area. Results for both studies are applicable only to these specific sites.

LEVEL 2 - EKMA

General Description

EKMA was developed by the EPA as an oxidant prediction relationship a step beyond ROLLBACK (7-9, 7-10). It is based on a series of curves relating observed early morning NO_x and non-methane hydrocarbon (NMHC) levels with the predicted maximum oxidant level downwind of a city center (see Figure 7-1). With the ozone isopleths, relative changes in ozone levels can be assessed as a function of changing NO_x and NMHC levels.

There are two ways to use EKMA. One is to use the standard set of ozone isopleths which are non-site specific and which reflect only one meteorological scenario to assess alternative control strategies. Another way is to make the set of isopleths city-specific. This is done by using the Kinetics Model and Ozone Isopleth Plotting Package (OZIPP) (7-8). By using OZIPP, the city specific factors including morning concentration of precursors; post 8 a.m. precursor emissions; mixing

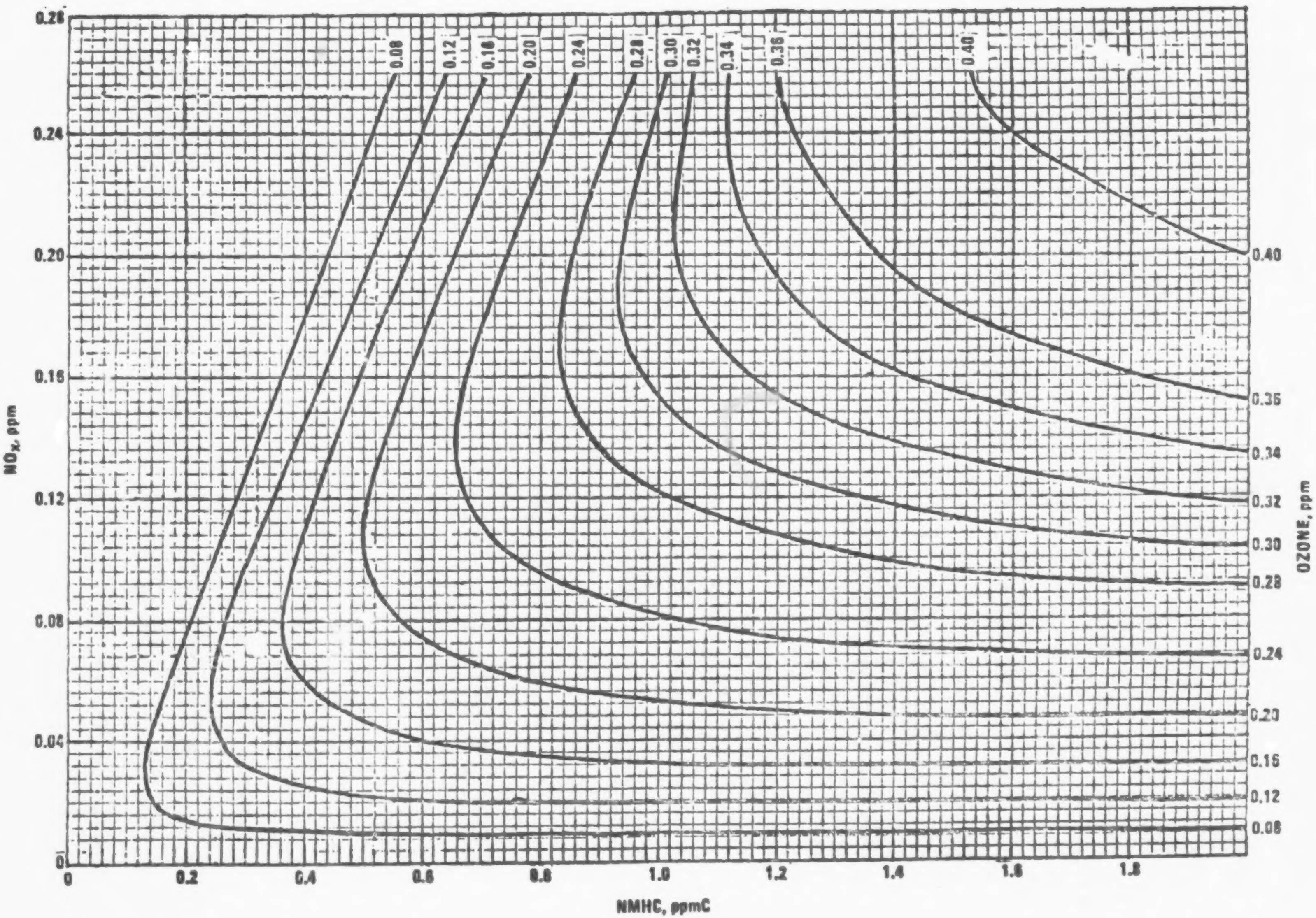

Figure 7-1. Example ozone isopleths used in EKMA

height; latitude, longitude and date; reactivity of precursor mix; transported ozone from upwind areas; and ozone and precursors from aloft are reflected in the generated ozone isopleth diagram. In other words, the city-specific factors can be considered in developing ozone controls.

EKMA is particularly useful for addressing the "hydrocarbon vs NO_x control" strategic oxidant control issue. It can do this because EKMA is basically a photochemical simulation model. Various combinations of hydrocarbon and NO_x control can be evaluated of their effectiveness in oxidant control.

The two EKMA procedures using either the standard ozone isopleths or OZIPP-generated isopleths are illustrated in Figures 4-2a and 4-2b respectively. EKMA application procedures are briefly discussed below. For more detailed information, the reader is referred to references 7-8, 7-9, and 7-10.

EKMA Using Standard Isopleths

The data required for this analysis are: ozone design value for the baseyear and the corresponding 6-9 am measured non-methane hydrocarbon (NMHC)/NO_x ratio, and the baseyear and future year hydrocarbon and NO_x regional emission inventory. Care must be exerted in determining a design value for the baseyear (details are discussed in Chapter 5). A selected design value for the baseyear is located on the set of isopleths (see Figure 7-1). Changes in hydrocarbon and/or NO_x levels needed to meet the oxidant standard can then be determined. A direct relationship is assumed between the hydrocarbon and NO_x measurements and emissions.

For each control strategy, a "target" emission rate of hydrocarbons and/or NO_x is determined. This is an absolute quantity. Comparing this with the projected future year emissions, the relative reduction required for each pollutant can be determined and the various control strategies can be developed.

EKMA Using OZIPP-Generated Isopleths

This approach tunes the model to a particular site. In addition to the data required by the standard method, the following is also needed:

- hydrocarbons split into propylene, butane, and aldehyde fractions
- NO_x/NO_2 ratio
- concentration of transported ozone and precursors
- mixing heights at 8 a.m. and 3 p.m.
- longitude, latitude and date

With this information, the computer program OZIPP is used to calculate maximum 1-hr average ozone concentrations. The results of OZIPP simulation are then used to generate an ozone isopleth diagram. The procedure for the use of this city specific isopleth diagram is the same as for the standard isopleth diagram previously described.

The additional labor costs associated with generating the city-specific isopleth are minimal. Given the total hydrocarbon and NO_x emissions, only relative ratios are needed to separate these two sets of compounds into their respective species classes. The meteorological data is easily taken from published sources. Transported ozone and precursor concentrations can be obtained from upwind measurements. Also, there are default values for all these inputs. Computation time to generate a set of city-specific isopleths is insignificant at 3 minutes on an IBM 370/168 computer.

EKMA cannot be used to predict absolute ambient oxidant values; rather, it is meant to be used for evaluating the effects of relative changes in precursor levels on oxidant formation on a regional basis. The EKMA model hasn't been validated or verified, though its chemistry has been verified in the sense that it is based on smog chamber tests.

LEVEL 3 - ROLLBACK MODEL

In the brief history of oxidant modeling for control strategy evaluation since the 1970 Clean Air Act, only rollback models have been sanctioned by the U.S. Environmental Protection Agency. These are the "Appendix J" rollback model and the rollback model. However, recent EPA announcements imply that Appendix J is no longer an acceptable method (7-9). The rollback model is based on the assumption that for any given region, reduction in hydrocarbon emissions will produce a proportional reduction in oxidant levels (7-11). Thus by using the rollback equation and knowing the ozone design value for the baseyear and transported ozone concentration, one could compute the percentage control for hydrocarbon emissions necessary to achieve the ozone standard.

Application Procedure

Figure 4-3 is a flow diagram of the application sequence for a rollback calculation. The first step is to determine an appropriate design value for the baseyear. A design value is the concentration with expected number of exceedances equal to 1. The procedures for estimating a design value from sampling data are discussed in Chapter 5 of this guidance. Once the design value is selected, the total non-methane hydrocarbon inventory for the region can be assembled on an annual basis. This inventory is represented by an annual total tonnage of emissions which becomes the foundation for hydrocarbon rollback calculations.

The rollback model also requires estimates of transported ozone concentrations for the baseyear. Transported ozone concentrations in the baseyear can be obtained from upwind measurements or estimated from published sources. Additionally, the addivity factors for transported ozone are required. Addivity factors for transported ozone generally range from 0.2 to 0.7; more detailed information can be found in Reference 7-9.

With the above-mentioned information, the relative hydrocarbon reduction, i.e., % reduction, necessary to meet the oxidant standard can be calculated using the rollback equations (see Chapter 4 of this guidance). This number applied to the baseyear emission inventory gives the allowable amount of NMHC that can be emitted and still meet the ozone standard for the baseyear and for any future year. The NHMC reduction for the future year is simply the projected emissions minus the allowable emissions divided by the projected emissions. The emissions control for the future year is thus identified given the total NMHC cannot exceed a stated quantity.

The rollback model is the cheapest and easiest to use. It is also generally acknowledged to be the least precise. No computer is necessary and only aggregated emissions data for the region are needed.

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7-11 Roth, P.M., S.D. Reynolds, G.E. Anderson, R.J. Polack, M.A. Yucke, and J.P. Killus, "An Evaluation of Methodologies for Assessing the Impacts of Oxidant Control Strategies," prepared for the American Petroleum Institute, Report No. EF76-112R, Systems Applications, Inc., San Rafael, California, August, 1976.

Chapter 8

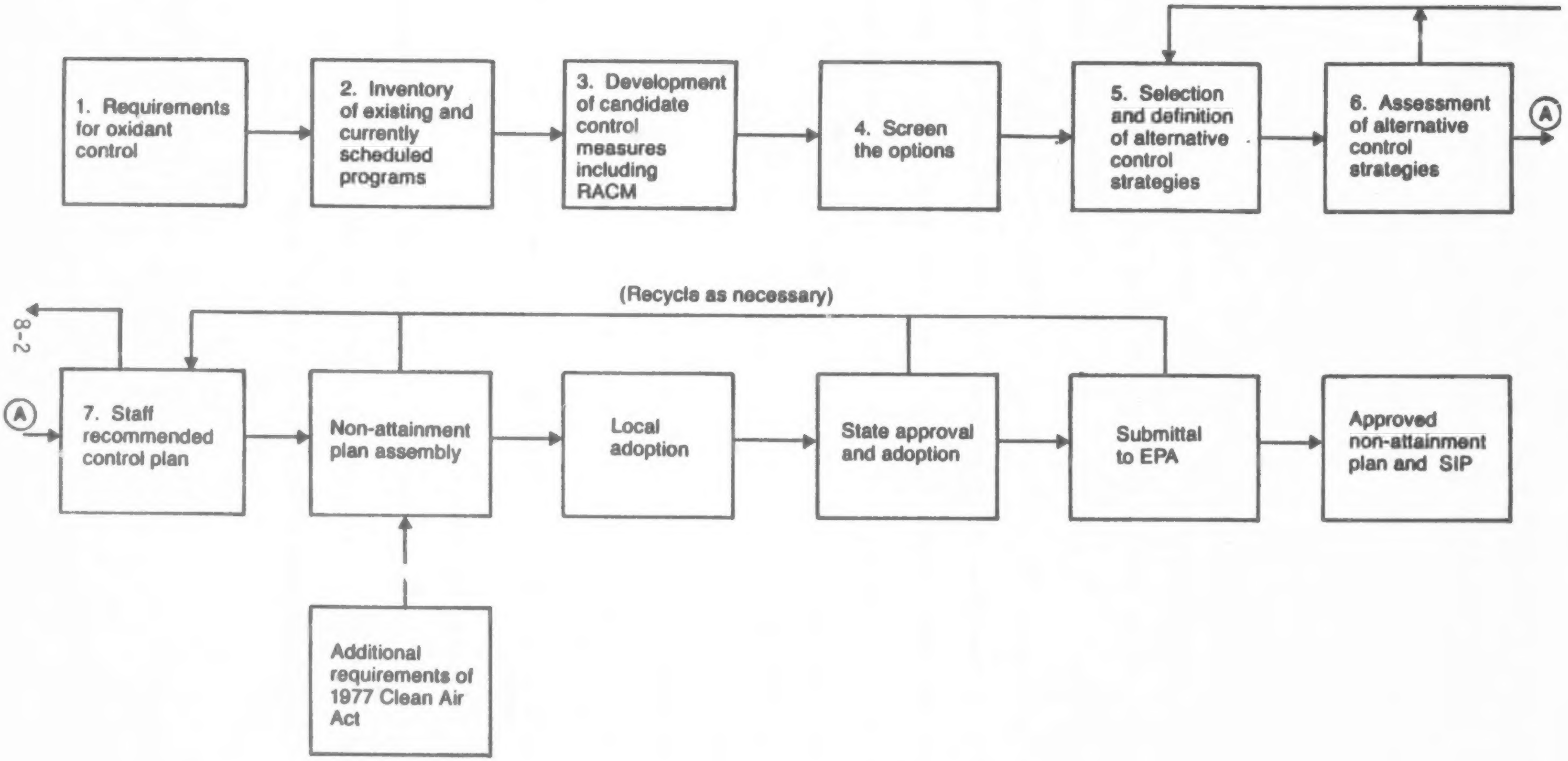
DEVELOPMENT AND ASSESSMENT OF OXIDANT CONTROL STRATEGIES

This chapter discusses the procedure for developing and evaluating alternative oxidant control strategies as part of a non-attainment area plan. As required by the Clean Air Act, an acceptable oxidant control plan must demonstrate that the oxidant standard will be attained and maintained as expeditiously as possible, but no later than 1987. To achieve this air quality goal, a wide range of control strategies must be considered. In addition to air quality, the health, welfare, economic, energy, and social impacts of alternatives considered must be analyzed. Formulation and assessment of alternative control strategies is one of the most complex tasks in a non-attainment planning effort.

To gain a perspective of the overall process, an overview of the procedure for developing oxidant control strategies is shown in Figure 8-1. This overview illustrates the time sequence of several major tasks. They are:

- Determination of requirements for oxidant control
- Inventory of existing and currently scheduled control programs
- Development of candidate control measures, including RACM's
- Screening the options
- Selection and definition of alternative control strategies
- Assessment of alternative control strategies, and
- Recommendation of an oxidant control plan.

Figure 8-1 Overview of Procedures for Developing Oxidant Control Strategy


1. Requirements for oxidant control
2. Inventory of existing and currently scheduled programs
3. Development of candidate control measures including RACM
4. Screen the options
5. Selection and definition of alternative control strategies
6. Assessment of alternative control strategies
A
(Recycle as necessary)
A
7. Staff recommended control plan
Non-attainment plan assembly
Local adoption
State approval and adoption
Submittal to EPA
Approved non-attainment plan and SIP
Additional requirements of 1977 Clean Air Act

Each of these tasks is discussed in the following sections. The remaining tasks shown in the Figure (local adoption, state approval and adoption, etc.) will be discussed in the next chapter.

DETERMINATION OF REQUIREMENTS FOR OXIDANT CONTROL

The initial step in developing an oxidant control strategy is to determine how much control is needed. The control requirements are determined by a series of technical analyses including determining the baseline oxidant concentrations and emission inventories for the baseyear and future years, and relating these oxidant concentrations to the precursor emissions. Control requirements have been discussed in Chapters 4 through 7 of this guidance. Overviews of the technical analyses which lead to the determination of requirements for oxidant control have been shown in Figure 4-1, 4-2, and 4-3, for the Level 1, 2, and 3 analyses, respectively.

Briefly, in the Level 1 analysis, a photochemical dispersion model is used to relate precursor emissions to ambient oxidant concentrations. The requirements for emissions (HC and/or NO_x) control are determined by comparing the predicted oxidant concentrations with the oxidant standard. The disaggregated emission inventory used in the analysis has detailed information for identifying the major emission sources, with spatial and temporal details as the primary targets of control.

In the Level 2 analysis, EKMA is used to determine the necessary emissions (HC and/or NO_x) reductions for attainment of the oxidant standard. In the Level 3 analysis, the percentage reduction of HC emission necessary to attain the oxidant standard is determined by the rollback calculations. The rollback model can be used to determine the control requirement for HC emissions only; NO_x emissions are ignored by this method.

INVENTORY OF EXISTING AND CURRENTLY SCHEDULED CONTROL PROGRAMS

Prior to actual development of alternative control measures, an accurate inventory of existing and planned programs which affect the ability of a non-attainment area to attain the oxidant standard is necessary. Therefore, an assessment of the effectiveness of ongoing and currently scheduled controls is made. This will provide a starting point for developing additional measures for further air quality improvement.

The inventory should be a complete accounting and characterization of all existing programs directly or indirectly affecting the oxidant concentrations in a non-attainment area, e.g., air pollution controls, land use policies and transportation programs. One direct way to obtain the necessary information is to survey all cities, counties, districts, regional agencies, and other political jurisdictions wholly or partly within the non-attainment area. Additionally, any applicable State and Federal air pollution control rules and regulations should be included.

In the inventory, a brief definition of the existing programs should be provided. Additionally, information on the program's current and future applications, estimated potential effectiveness, responsible agency, and implementation status and schedules should be included, if possible. It is also suggested that all the existing and planned programs be classified into appropriate categories, such as technological control, land use management, transportation control, etc. A complete and well-documented inventory of the existing and planned programs provides a good starting point for development of additional measures for consideration.

DEVELOPMENT OF CANDIDATE CONTROL MEASURES INCLUDING RACT'S

After the initial inventory of the existing and planned control programs is completed, the next task is to inventory many of the still remaining control measures which might be considered for further air quality improvement. Any measures which have a potential for reducing or preventing VOC and/or NO_x emissions should be included. Additionally, the measures which will result in spatial and/or temporal redistribution of emissions within a non-attainment area should also be considered. In some cases, the measures which are considered may in fact already be in existence, e.g., transit service and vehicle exhaust emission standards. What is considered then is a further strengthening or expansion of the program in place, e.g., more transit service or more stringent vehicle exhaust emission standards.

All the reasonably available control technologies (RACTs) identified by EPA must also be included. The Clean Air Act Amendments of 1977 require the use of RACTs--at a minimum--in all areas of the country where the oxidant standard is being exceeded. Up to the present, EPA has identified RACTs, also known as Control Technology Guidelines (CTGs) for 12 categories of sources. Additional source categories of VOC for which EPA will identify RACTs are listed in Table 8-1.

In addition to RACTs, EPA has published a list of 19 reasonably available transportation control measures (RATCMs) (see Table 8-2). A non-attainment plan should consider all of the 19 RATCMs for adoption,

TABLE 8-1. FORTHCOMING CTGs FOR STATIONARY VOC SOURCES

GROUP I*

Large Appliance Manufacture
Magnet Wire Insulation
Gasoline Bulk Plants
Metal Furniture Manufacture
Petroleum Liquid Storage,
  Fixed Roof Tanks
Degreasing
Bulk Gasoline Terminals
Petroleum Refinery Vacuum Systems,
  Waste Water Separators and
  Process Unit Turnaround
Service Stations, Stage I

GROUP II

Petroleum Refinery Fugitive
  Emissions (leaks)
Surface Coating of Other Metal
  Products - Industrial
Pharmaceutical Manufacture
Rubber Products Manufacture
Paint Manufacture
Vegetable Oil Processing
Graphic Arts (Printing)
Flat Wood Products
Service Stations, Stage II
Petroleum Liquid Storage
  Floating Roof Tanks

GROUP III

Ship and Barge Transport of
  Gasoline and Crude Oil
Organic Chemical Manufacture
  Process Streams
  Fugitive (Leaks)
Dry Cleaning
Wood Furniture Manufacture
Architectural and Miscellaneous
  Coatings

GROUP IV

Organic Chemical Manufacture
  Waste Disposal
  Storage and Handling

OTHERS

Natural Gas and Crude Oil
  Production

Adhesives

Other Industrial Surface
  Coatings

Auto Refinishing

Other Solvent Usage

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*CTGs have been published for this group.

Source: Reference 8-1.

TABLE 8-2. LIST OF REASONABLY AVAILABLE TRANSPORTATION CONTROL MEASURES

MEASURES
Inspection/maintenance
Vapor recovery
Improved public transit
Exclusive bus and carpool lanes
Areawide carpool programs
Private car restrictions
Long-range transit improvements
On-street parking controls
Park and ride and fringe parking lots
Pedestrian malls
Employer programs to encourage car and van pooling, mass transit, bicycling and walking
Bicycle lanes and storage facilities
Staggered work hours
Road pricing to discourage single occupancy auto trips
Controls on extended vehicle idling
Traffic flow improvements
Alternative fuels or engines and other fleet vehicle controls
Other than light duty vehicle retrofit
Extreme cold start emission reduction programs

Source: Reference 8-1.

or documentation must be made for not adopting the RATCMs.

In short, the guiding principle for this task is to develop as complete an inventory of candidate control measures as possible. A suggested approach is to have each of the agencies participating in the plan development prepare a list of options for their area of expertise and/or responsibility. For example, the transportation agency prepares transportation control options, the air pollution control agency prepares stationary source control options, etc. Properly executed, this task will result in a wide range of options for the staff and other decision-making bodies to choose from in developing alternative control strategies.

SCREENING THE OPTIONS

The purpose of this task is to screen the inventory of options down to a more manageable size for further evaluation. This initial screening should be based on technical effectiveness, applicability, and other preliminary criteria. For example, RACTs for all 12 CTG source categories of VOC are supposed to be considered in all non-attainment plans, however, RACTs for the source categories which do not exist in a particular non-attainment area should be eliminated from consideration. Information on the effectiveness of various measures can be found in EPA's CTG document series (see Appendix B). The screening primarily on the basis of technical effectiveness will avoid the technical staff making political judgments regarding an option's political merits and implementability. Elected officials and the public could judge its political merits and public acceptability in the later phase of the plan development. This task will result in a refined list of options which are considered as technically effective and applicable for the non-attainment area.

SELECTION AND DEFINITION OF ALTERNATIVE CONTROL STRATEGIES

Up to this stage of the plan development process, the measures represent nothing more than "ideas". For example, "Ramp metering" is listed only as an "idea" without any detailed information regarding the implementation. This task will define the measures in a more detailed fashion. For example, where to apply ramp meters and when to start the implementation will be defined and the effectiveness of that particular application will be estimated. The control measures for mobile and stationary sources have traditionally been direct controls. As such they should be specified in precise terms. Many of the land use planning and transportation measures are indirect controls. Thus, they may be described in more general terms.

In the process of defining the detailed measures the possibility of establishing and implementing them is concurrently evaluated. Availability of resources necessary to implement and enforce the measure, time requirements, and legal authority are among the factors that should be considered. Additionally, compatability of the measures should also be considered. For example, a successful vanpool and carpool program may not be considered as compatible with a measure calling for capital improvement of a mass transit system. During the evaluation process, the number of feasible measures will be reduced, and it is conceivable that it may clearly indicate the superiority of certain measures over others. As a result, this task will develop several preliminary packages of alternative control strategies for further assessment.

Public and local government and intergovernmental coordination is especially important during this grouping process. Understanding and agreements should be obtained regarding those measures to be eliminated from further consideration and those measures to be included for further assessment. Public participation and intergovernmental cooperation are discussed in detail in Chapter 3 of this guidance.

ASSESSMENT OF ALTERNATIVE CONTROL STRATEGIES

This task is to conduct a systematic assessment of the various packages of control strategies selected in the previous task. The objective is to identify an optimum package of control strategies for inclusion in the non-attainment plan. The control strategies still under consideration at this point are effective in emission reduction. The next step is to quantify their effectiveness. From this a technical ranking of the control strategies can be made.

In addition to technical effectiveness, the overall economic and institutional impacts of the control strategies must be analyzed. Each control strategy will impact the community in various ways. These impacts may be beneficial to one segment of the community and adverse to another. As mandated by the Clean Air Act Amendments of 1977, a non-attainment plan should include identification and analysis of economic, social, welfare, energy, health, and air quality effects of the control strategies. The final selection of control strategies should be based an on overall evaluation of all appropriate factors.

In the following paragraphs, the above-mentioned technical, economic, institutional and other effects of control strategies are discussed and an overall procedure leading to an assessment of these effects is recommended.

Technical Effectiveness

In the previous tasks, the technical effectiveness of the individual control strategies has been identified and analyzed. Based on that information, the purpose of this task is to analyze the composite effectiveness of various packages of control strategies. The estimated effectiveness of a control package must then be evaluated against the requirements for oxidant control previously determined. A selected package of control strategies should meet the necessary requirements and provide for attainment of the standard as expeditiously as practicable. In the Level 2 (EKMA) and Level 3 (Rollback) analyses, attainment of the oxidant standard is determined by calculating whether the required emission reduction is met. In the Level 1 analysis, the effectiveness of a control package is translated into the appropriate variable or into an adjustment of the emission inventory. Then, the adjusted emission inventory is input to a photochemical dispersion model to project ambient oxidant concentrations to determine whether the oxidant standard will be attained.

Economic Considerations

Economic considerations of control strategies should include cost-benefit and cost-effectiveness analyses. There are direct and indirect costs of oxidant control strategies. The direct costs include all expenditures required of a source, including capital construction costs, operational and maintenance costs, and administrative/regulatory costs. The indirect costs include the incremental costs to sectors of economy other than an emission source, such as price changes for materials, changes in property value, etc.

The benefits of control strategies include better protection of health, vegetation and materials due to cleaner air. Some control strategies may generate revenues, e.g., increasing tolls as a means to discourage auto driving. Cost-effectiveness can be measured in terms of the cost ($) per unit mass (ton) of emission reduced or prevented. Since various control strategies will have the same benefits--the control of oxidant pollution--the cost-effectiveness (dollars per ton of emission reduced) may serve as a common indicator for ranking various control measures.

Not all of the above mentioned costs and benefits can be measured quantitatively. The costs of many technological control measures, e.g., a device applied to an emission source, a fuel switch, etc. may be quantified quite precisely. However, for those control strategies described only in general terms, e.g., land use planning and emission density zoning, the cost estimate can only be qualitative. In this case, the assessment may have to rely on subjective judgment. Cost data sources for a number of selected control strategies can be found in References 8-2 and 8-3.

Since most control strategies will be implemented over a period of time, the associated costs should be computed in terms of present value. The resultant present values should be converted into equivalent annual costs so that all costs can be compared on a common basis. The procedure for cost analysis can be found in many engineering economics textbooks. The factors (interest rate, rate of return, etc.) used in computing the costs should be consistent for all control strategies. The total costs of a control strategy should be distributed to the appropriate recipients (consumer, owner, government, etc.).

Institutional Impacts

Institutional impacts of control strategies should be assessed in terms of implementability, public acceptance (social impact), welfare, legal authority, social effects and others. These institutional impacts are difficult to measure in quantitative terms.

Public hearings and review meetings are probably the best way to measure some of the institutional impacts. Public acceptability, political merits and implementability of each control strategy are best judged by elected officials and the public whom are likely to be affected by the proposed strategies. Adequate time should be provided for elected officials and the public to review the plan or alternative controls. In the evaluation of public opinions on control strategies, care should be taken to ensure that undue weight is not given to opinions of special interest groups.

Other institutional factors such as the welfare costs and social effects of control strategies are even more difficult to assess than political merits and public acceptability. The EPA AQMP Guideline Series (8-2) suggests using social indicators as criteria to assess the social effects of control strategies. Ranking the strategies in terms of their social effects can be done by comparing the impact of each strategy upon each of the social indicators. The procedures for ranking strategies in terms of their social effects are discussed in detail in Reference 8-4.

Overall Assessment

To facilitate an overall assessment of various control strategies, a decision matrix which includes all the above-mentioned technical, economic, and institutional factors is suggested. Table 8-3 is an example evaluation matrix developed by the Washington Environmental Research Center. Table 8-4 is the evaluation format suggested in the EPA AQMP document series (8-2). As a rule, the first column of the evaluation matrix should include all the control strategies to be assessed; the evaluation factors (cost, benefit, social effects, etc.) are listed in columns 2 and so on.

For each control strategy, a relative score with respect to each of the evaluation factors is given in an appropriate column. For the factors which can be quantified, (costs, emission reduction, cost effectiveness, etc.), ranking the strategies is relatively easy. For the factors which cannot be quantified, (social effects, welfare costs, etc.), ranking must rely upon subjective judgment. An appropriate methodology should be used to weigh each of the evaluation factors; thus, an overall ranking of the strategies based upon weighed evaluation factors can be determined. The completed assessment matrix can then be carried forward for further evaluation. The public and various governing bodies of the political jurisdictions within the non-attainment area will probably make the final judgment of the control strategies.

STAFF-RECOMMENDED CONTROL PLAN

After completion of the overall assessment process, an optimum package of control strategies is identified and recommended for inclusion in the non-attainment plan. In addition to other requirements, the recommended control plan must demonstrate numerically that the oxidant standard would be achieved as expeditiously as

TABLE 8-3. Washington Environmental Research Center (WERC) Matrix

	Implementation Tool	% Effectiveness	% Reduction	ECONOMIC CONSIDERATIONS 1 - Most Expensive 2 - Moderately Expensive 3 - Least Expensive												Social Responsiveness					Administrative Considerations					
				Direct Costs				Admin. Costs				Social Costs									Control Application					
				To Polluter	To Consumer	To Government	Other	Program Mgmt.	Enforcement	Monitoring	Other	Area Income	Area Employment	Regional Prices	Other	Most Acceptable	.	.	.	Least Acceptable	Flex. 1-Most 2. - 3-Least	Legal Precedent Exists Y-yes N-No	Continuous	Noncontinuous	Selective	Uniform
Strategy 1																										
Strategy 2																										
Strategy 3																										

Source: Reference 8-1.

TABLE 8-4. FORMAT OF DECISION MATRIX SUGGESTED IN EPA AQMP GUIDELINES

Area of AQMA where inapplicable ____________________

Pollutant __________ Reduction or redistribution required __________

Measure	Applicable (yes or no)	Sources affected	Emissions reduced or redistributed (tons)	Economic cost ($)	Cost $/ton	Social impact number of*		
						+	0	-
Land Use and Planning								
1. Emission allocation								
2. Regional development planning								
3. Emission density zoning								
4. Zoning approval								
5. Transportation control								
6. Emission charges								
7. Transfer of emission source location								
8. Indirect source review								
9. Environmental impact statements								
Emission Control								
1. New Source Performance Standards								
2. More stringent control on existing sources								
3. Phase out on prohibition								
4. Fuel conversion								
5. Fuel conservation and utilization								
6. Combination of sources								
7. Special operating conditions								
8. Stack height regulations								
9. Control of fugitive dust								
Totals								

*To be used if short approach is used.

Cost base year:

Total discounted Cost ($):

Emissions Reduced or Redistributed (tons):

Avg. Cost/ton:

Social Evaluation Score:

Rank:

Combined Socioeconomic Rank of Strategy:

(Specific remarks or comments on individual measures or the overall strategy should be appended)

Source: Reference 8-2.

practicable, but no later than 1987. A summary of the recommended control plan should be prepared, and supporting technical data and the analysis and decision processes should be documented and retained for future reference.

In the recommended plan, a concise description of the actions should be provided. In addition, the plan should include the agencies responsible for implementation, the implementation schedule, the costs of the plan, sources of finances, the direct benefits of the plan (in terms of emission reductions), and other relevant environmental, institutional, financial, economic, and social information.

The recommended control plan and the other additional requirements of the Clean Air Act will then be assembled as a complete non-attainment plan. This plan will subsequently go through local adoption, state approval and adoption, and EPA approval processes.

REFERENCES

8-1 U.S. Environmental Protection Agency, "Workshop on Requirements for Non-Attainment Area Plans - Compilation of Presentations," workshop held in San Francisco, California, March, 1978.

8-2 U.S. EPA "Guidelines for Air Quality Maintenance Planning and Analysis, Volume 2: Plan Preparation," publication no. 450-4/74-002.

8-3 U.S. EPA, "Guidelines for Air Quality Maintenance Planning and Analysis, Volume 3: Control Strategies," publication no. 450-4/74-003.

8-4 Klee, A.J., "The Role of Decision Models in the Evaluation of Competing Environmental Health Alternatives." Management Science, Journal of the Institute of Management Sciences, 18, No. 2, October, 1971.

Chapter 9

PLAN REVIEW, ADOPTION AND APPROVAL PROCESS

The Clean Air Act requires that the State Implementation Plan be adopted by a state after a public hearing. The Act does not specify a local process for adoption of non-attainment plans. As with other parts of the air quality planning program, the nature and schedule of the local approval process may vary from region to region, depending on the geographic size of the non-attainment planning area, the number of local jurisdictions in the area, and the number and authority of other agencies involved in the planning program.

PROVIDING ADEQUATE TIME FOR PUBLIC REVIEW

EPA regulations (40 CFR Part 51) require that any draft of a major implementation plan revision (including any of six elements listed in 51.244 of the regulations) shall be submitted to the state and areawide clearinghouses for review and comment. The review-and-comment period is established at 45 days, and comments received during that time are to be considered before an SIP revision is adopted.

As a practical matter, experience in preparing the 1979 plan submissions suggests that a 45-day review-and-comment period is not adequate. To ensure effective and informed decision-making, review periods of 60-120 days or longer are likely. If control programs recommended are likely to be highly controversial, requests will probably be made for more public review time. Schedules for 1982 plan revisions should provide for some margin toward the end of the plan revision process for schedule changes to accommodate, where appropriate, public requests for extensions in the review period.

AVAILABILITY OF REVIEW DOCUMENTS

Plan revision documents should be made available well in advance of public hearings. Where possible, non-technical summaries should be prepared. All material should be readily available to interested parties, and local libraries and other public locations can be used effectively in ensuring access to information about what is recommended and why.

DEMONSTRATION OF REASONABLE FURTHER PROGRESS

The 1977 Clean Air Act Amendments provide an important concept missing from the 1970 Act--the requirement for "reasonable further progress." Section 171 defines the term "reasonable further progress" as annual incremental reductions in emissions of the applicable air pollutant--(including substantial reductions in the early years following approval or promulgation of plan provisions under Part D and Section 110(a)(2)(I) and regular reductions thereafter)--sufficient, in the judgment of the EPA Administrator, to provide for attainment of the applicable national ambient air quality standard by the date required in Section 172(a).

Section 172(b)(3) provides that the "non-attainment" SIP submittal shall require, in the interim, reasonable further progress (RFP) (as defined above), including such reduction in emissions from existing sources in the area as may be obtained through the adoption, at a minimum of, reasonably available control technology.

Non-attainment plans should include an RFP schedule. The purpose of an RFP schedule is to verify that the emission reductions obtained are being accomplished at a reasonable and efficient rate so that attainment by the prescribed time will take place. Where only violations of the annual primary NAAQS are involved, RFP is intended to represent the application of effective controls as expeditiously as practicable. RFP schedules to correct violations of the secondary standards are again intended to depict a timetable for compliance within "a reasonable time." Where attainment of the oxidant standard can not be accomplished by 1982, then an RFP schedule reflecting application of reasonably available control measures will be acceptable as long as attainment is accomplished by the agreed upon date (not to exceed 1987).

For the majority of cases, EPA expects that RFP schedules will be linear. A linear RFP schedule is thought by EPA to be completely within the intent of the Section 171 definition. That is, such a line would effect substantial reductions in the early going and not put off accomplishing most of the required reductions until the last year(s). A linear schedule is also thought to be a stringent timetable to accomplish emission reductions in light of the lag time for installing control technology.

In terms of answering the 1979 plan requirement to show RFP, the submission of a linear RFP schedule will be acceptable even if initially a linear timetable would be thought inappropriate. Unless the state or region on its own chooses to submit a detailed nonlinear RFP, a linear schedule for 1982 attainment SIPs will be acceptable to EPA. Such a schedule is thought to reflect a reasonable rate of progress considering the relatively short time frame allotted for attainment (maximum of 4 to 5 years). To routinely require a detailed RFP may direct critical resources from accomplishing the actual attainment. Only in certain cases where the controls necessary for attainment cannot be reasonably applied as quickly as required by a linear RFP would it be in the best interest of a state or region to develop and submit a "less-than-linear" RFP schedule.

The linear assumption is initially acceptable for all 1979 plan submittals. Of course, some of the plans, particularly those attaining standards after 1982, may have to amend their schedules over the year following the 1979 submittal to make RFP more meaningful. Where the linear assumption is thought to be inappropriate, an acceptable alternative RFP schedule must be submitted to the Regional Administrator. Such nonlinear schedules should be developed over the year following the 1979 plan submission. EPA acknowledges that developing such RFPs is more resource intensive and should be attempted only when absolutely necessary.

A non-linear RFP will typically be developed in the case of oxidant plans that fail to attain by 1982 but do so not later than 1987. Herein, the aggregate nature of the emission inventory must be considered. Individual RFP schedules for each general component of the 1977 emissions inventory (i.e., mobile, major stationary, and minor/area sources) must be developed. For post 1982 oxidant SIPs, reductions from mobile sources until 1983 are expected to follow as a minimum a schedule consistent with the Federal Motor Vehicle Control Program (FMVCP) and the application of RACMs. Beyond 1982 until attainment, the reductions from mobile sources will reflect the imposition of other measures (as necessary) as well as the continuing cleanup accomplished by the FMVCP. Major stationary sources correspondingly must be controlled until 1982 at least as effectively as they would under an RFP schedule exhibiting the application of RACT. After 1982 and until attainment (no later than 1987) the schedule for reductions will reflect the application of other control measures. A linear assumption can be made for the portion of the RFP schedule beyond 1982. Finally, a linear assumption is appropriate throughout the RFP schedule for controlling minor and area (other than mobile) source growth.

COMPLIANCE WITH EPA RACT MEASURES

The Clean Air Act Amendments of 1977 require the use of reasonably available control technology--at a minimum--in all areas of the country where a standard is being exceeded. EPA has identified reasonably available control technologies (RACTs), also known as control technology guidelines (CTGs), for 12 categories of sources. Controls for additional source categories are forthcoming.

Local districts and air quality planning organizations should review their regulations and, by comparing the regulations with the CTG requirements, determine if all RACT measures are being implemented. Where they are not, local agencies should proceed promptly with development of regulations to comply with the 1977 Clean Air Act requirements for implementation of all reasonably available control technologies.

DEMONSTRATION OF LEGAL, FINANCIAL AND MANPOWER COMMITMENT TO IMPLEMENTATION

This requirement is established in S. 172 of the act. The requirement itself is a principal reason why implementing agencies should be directly involved in the planning process and adoption of the non-attainment plan. The Act requires that the SIP be legally enforceable. For example, stationary source controls are primarily implemented by local or regional districts by regulation. A demonstration of commitment to implement stationary source control measures occurs only when the local district agrees to carry out the measures and it has the authority to do so. Similar demonstrations for other control strategies can only occur as part of the plan development and approval process. For actions assigned to the state, demonstrated commitment to implement control measures--as opposed to expressions of willingness to carry out control measures made by state agencies prior to local adoption--can only be reasonably expected to occur after the plan is approved locally and submitted to the state.

For actions for which there does not yet exist legal authority, demonstrated commitment can be reasonably expected to consist of: a) a willingness to carry out a reasonably available control measure, and b) a willingness to seek legal authority. Actions assigned by locally adopted plans to the State but for which no legal authority to implement the measures exist require that the State seek legal authority, or provide adequate documentation of the infeasibility of the proposed action. Preferably this documentation should occur during the review-and-comment period prior to local adoption, so the plan may be revised. Otherwise the locally adopted plan must be revised at the state level or by a local-state negotiation process.

Financial and manpower commitments are dealt with using a similar line of reasoning. Unless an agency demonstrates lack of financial and manpower commitments, it can reasonably be expected that such commitments are available if an agency agrees to carry out a control measure.

REFERENCES

9-1 Environmental Protection Agency, Workshop on Requirements for Nonattainment Area Plans, revised edition, April, 1978.

Chapter 10

THE CONTINUING PLANNING PROCESS

The continuing air quality planning process should logically follow from the process and work accomplished during the initial planning period. Two key tasks to be carried out during the continuing planning process are to: 1) respond to issues raised during state and federal review of the 1979 plan submittal when such issues cannot be satisfactorily resolved prior to plan approval at the state or federal level, and 2) monitor implementation of initial plan control measures to ensure that reasonable further progress (described in Chapter 9) is achieved. The first key task is self-explanatory; the second deserves further explanation.

TRACKING REASONABLE FURTHER PROGRESS

RFP is to be tracked primarily by a yearly assessment of the net reductions to actual emissions (including growth) that have taken place. A summary of these reductions will be submitted as an annual report. The S. 171 definition of RFP is non-specific as to what type of emissions inventory should be tracked and reported on an annual basis. For several reasons, however, EPA believes that the intent of Congress was to monitor yearly trends in actual emissions to assess if RFP is being accomplished. Section 172(b)(4) requires emission inventory development on an actual emissions basis and sufficient revisions thereafter to enable a determination regarding RFP to be made. The tracking of actual emissions also seems to be reasonable in that quality trends are best linked to changes in this emissions inventory. Finally, actual emissions are also important since they are most likely the basis for determining what controls are needed for cleanup.

The annual report should summarize how total actual emissions have been reduced relative to the applicable RFP milestones. Only where special non-linear RFPs are applicable will the annual report be more specific than reporting total actual emissions (i.e., mobile, major stationary, and minor/area). Although not formally required, a state or local agency might also report or at least keep track of how maximum and allowable emissions have changed over the same time period.

Section 171 defines RFP in terms of annual emission reductions and does not mention changes in air quality directly. EPA's position is that air quality changes should be taken into account, at least qualitatively, in determining if RFP is being accomplished. That is, the intent of reviewing air quality changes with the associated emission reductions is to ensure that the reductions accomplished are meaningful in terms of actual air quality improvement.

The annual report for RFP or the air quality trends data are expected to identify from time to time the existence of some control strategy or implementation problems. In fact, this is precisely the intended function of RFP. That is, the RFP report attempts to identify problems so that they can be resolved without jeopardizing attainment by the prescribed date.

Three types of problems can occur. The first is simply failing to obtain sufficient actual emission reductions to meet the specific RFP milestone. Such a problem could be the result of excessive growth (major and/or minor area growth), enforcement problems, or the lag time to install control equipment.

The second problem identified is poor air quality improvement despite the accomplishing of all the emission reductions called for under RFP. Conceivably, this problem could be caused by the persistence of unusual meteorological conditions, overestimating the value for cleaning up certain emissions sources (bad emission factors), or the omission of key sources from the inventory altogether. The latter more specifically refers to the lack of control on key sources which have not been included in the initial emissions inventory developed for the non-attainment area.

The third and final potential problem is the inability of maximum emissions to decline at an acceptable rate even though actual emissions have been reduced in accordance with the RFP schedule. This problem will likely be noticed by only those states or local areas tracking trends in maximum emissions. The problem may occur due to delays in converting SIP allowable emission limits that far exceed what a source could physically emit to more realistic emission rates or the failure to constrain the operating hours and/or capacity use of key sources as appropriate.

In general, no sanctions will be imposed when problems such as those mentioned are identified if a justification is presented that demonstrates that attainment by the prescribed date is not jeopardized. However, in many cases some additional corrective action(s) may be necessary.

WORK PROGRAM SUBMITTALS

The 1979 plan submittals, plus issues raised in the state/federal approval process, should provide adequate task and schedule detail for submittal of work programs for the first round of S. 175 grants. Each year's previous work, plus information gained from tracking RFP and changes in EPA requirements, should be used in the succeeding work programs. The key to the work, however, will be the 1982 plan submittal and the necessity to keep the program on track to meet the plan submittal deadline.

Appendix A

Bibliography of Urban System Models

Urban system modeling is a primary tool for predicting the size and distribution of land use activities in an urban area; the modeling results provide necessary information for estimating mobile and area-source emissions. If a photochemical dispersion model is to be used as a primary tool in a non-attainment planning analysis, a regionwide, gridded emission inventory is needed. In this case, urban system modeling is the best way to generate the urban activity data necessary for spatial and temporal resolution of emissions. In a non-attainment planning effort, urban system modeling, if required, is usually conducted by regional planning agencies.

Urban activity data required to project emissions include the levels and distribution of land use, population, employment, housing, and travel activities. A system capable of producing the necessary information is generally composed of the following types of models:

- Regional Projection Models
    - Regional Demographic Model
    - Regional Econometric Model, etc.
- Activity Allocation (Zone Level) Models
    - Basic Employment Model
    - Projective Land Use Model (PLUM)
    - Urban System Model (USM)
    - Empiric Model, etc.
- Travel Demand Forecasting Models
    - Trip Generation Model
    - Trip Distribution Model
    - Modal Split Model
    - Network Assignment Model, etc.

The following is a compilation of several of the most widely used models. A number of special-case models (i.e., the models which cannot be easily applied to other non-attainment areas) are not included in the list.

REGIONAL PROJECTION MODELS

ABAG Regional Demographic Model (APPLE); ABAG Regional Econometric Model:

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ACTIVITY ALLOCATION (ZONE LEVEL) MODELS

EMPIRIC Activity Allocation Model:

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APPENDIX B

EPA CONTROL TECHNOLOGY GUIDELINE DOCUMENTS*

Control of Volatile Organic Emissions from Existing Stationary Sources Volume V: Surface Coating of Large Appliances - EPA-450/2-77-034.

Control of Volatile Organic Emissions from Existing Stationary Sources Volume IV: Surface Coating for Insulation of Magnetic Wire - EPA-450/2-77-033.

Control of Volatile Organic Emissions from Bulk Gasoline Plants - EPA-450/2-77-035.

Control of Volatile Organic Emissions from Existing Stationary Sources Volume III: Surface Coating of Metal Furniture - EPA-450/2-77-032.

Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed Roof Tanks - EPA-450/2-77-036.

Control of Volatile Organic Emissions from Solvent Metal Cleaning - EPA-450/2-77-022.

Control of Hydrocarbons from Tank Truck Terminals - EPA-450/2-77-026.

Control of Refinery Vacuum Producing Systems, Wastewater Separators, and Process Unit Turnarounds - EPA-450/2-77-025.

Control of Volatile Organic Compounds from Use of Cutback Asphalt.

Control Volatile Organic Emissions from Existing Stationary Sources Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks - EPA-450/2-77-008.

Design Criteria for State I Vapor Control Systems - Gasoline Service Stations.

Control of Volatile Organic Emissions from Existing Stationary Sources Volume I: Control Methods for Surface-Coating Operations EPA-450/2-76-028.

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*Reproduced from "Workshop on Requirements for Non-Attainment Area Plans--Compilation of Presentations," U.S. Environmental Protection Agency, March, 1978.

EPA 450/2-73-002	A Technique for Calculating Overall Efficiencies of Particulate Control Devices. 8/73.
EPA 450/2-74-002A	Background Information for New Source Performance Standards: Primary Copper, Zinc, and Lead Smelters. Vol. 1 - Proposed Standards. 10/74.
EPA 450/2-74-008	Air Pollution Control Engineering and Cost Study of the Ferroalloy Industry. 5/74.
EPA 450/2-74-009A	Background Information on National Emission Standards for Hazardous Air Pollutants, Proposed Amendments to Standards for Asbestos and Mercury. 10/74.
EPA 450/2-74-017A	Background Information for Standards of Performance: Electric Arc Furnaces in the Steel Industry. Vol. 1 - Proposed Standards. 10/74.
EPA 450/2-74-017B	Background Information for Standards of Performance: Electric Arc Furnaces in the Steel Industry.
EPA 450/2-74-018A	Background Information for Standards of Performance: Electric Submerged Arc Furnaces Producing Ferroalloys. Vol. 1: Proposed Standards. 10/74.
EPA 450/2-74-018B	Background Information for Standards of Performance: Electric Submerged Arc Furnaces for Production of Ferroalloys. Vol. 2: Test Data Summary. 10/74.
EPA 450/2-74-018C	Background Information for Standards of Performance - Electric Submerged Arc Furnaces for Production of Ferroalloys. Vol. 3 - Supplemental Information. 4/75.
EPA 450/2-74-019A	Background Information for Standards of Performance: Phosphate Fertilizer Industry. Vol. 1 - Proposed Standards. 10/74.
EPA 450/2-74-019B	Background Information for Standards of Performance: Phosphate Fertilizer Industry. Vol. 2: Summary of Test Data. 10/74.
EPA 450/2-74-020A	Background Information for Standards of Performance: Primary Aluminum Plants. Vol. 1 - Proposed Standards. 10/74.
EPA 450/2-74-020B	Background Information for Standards of Performance: Primary Aluminum Plants. Vol. 2: Summary of Test Data. 10/74.
EPA 450/2-74-020C	Background Information for Standards of Performance: Primary Aluminum Industry. Vol. 3 - Supplemental Information. 1/76.

EPA 450/2-74-021A	Background Information for Standards of Performance: Coal Preparation Plants. Vol. 1: Proposed Standards. 10/74.
EPA 450/2-74-021B	Background Information for Standards of Performance: Coal Preparation Plants. Vol. 2 - Summary of Test Data. 10/74.
EPA 450/2-74-021C	Background Information for Standards of Performance: Coal Preparation Plants. Vol. 3 - Supplemental Information. 1/76.
EPA 450/2-75-009	Standard Support and Environmental Impact Statement - Emission Standard for Vinyl Chloride. 10/75.
EPA 450/2-75-009B	Standard Support and Environmental Impact Statement: Volume 2 Promulgated Emission Standard for Vinyl Chloride. 1976.
EPA 450/2-76-002	State Implementation Plan Emission Regulations for Sulfur Oxides - Fuel Combustion. 3/76.
EPA 450/2-76-012	Field Evaluation of Reid Jacket Vapor Control System. 1976.
EPA 450/2-76-014A	Standards Support and Environmental Impact Statement: Vol. 1 Proposed Standards of Performance for Kraft Pulp Mills. 1976.
EPA 450/2-76-016A	Standards Support and Environmental Impact Statement: Vol. 1 Proposed Standards of Performance for Petroleum Refinery Sulfur Recovery Plants. 1976.
EPA 450/2-76-028	Control of Volatile Organic Emissions from Existing Stationary Sources: Vol. 1 - Control Methods for Furnace Coating Operation. 1976.
EPA 450/2-76-030A	Standards Support and Environmental Impact Statement: Vol. 1 - Proposed Standard of Performance for Lignite-Fired Steam Generators. EPA: OAQPS 1976.
EPA 450/2-77-001A	Standards Support and Environmental Impact Statement: Vol. 1 - Proposed Standards of Performance for the Grain Elevator Industry. EPA: OAQPS 1977.
EPA 450/2-77-005	Control of Fluoride Emissions from Existing Phosphate Fertilizer Plants: Final Guideline Document. EPA: OAQPS 1977.
EPA 450/2-77-007A	Standards Support and Environmental Impact Statement: Vol. 1 - Proposed Standards of Performance for Lime Manufacturing Plants. EPA: OAQPS 1977.

EPA 450/2-77-008	Control of Volatile Organic Emissions from Existing Stationary Sources: Vol. II - Surface Coating of Cans, Coils, Paper, Fabric, Automobiles and Light Duty Trucks. EPA: OAQPS 1977.
EPA 450/2-77-019	Final Guideline Document: Control of Sulfuric Acid Mist Emissions from Existing Sulfuric Acid Production Units. EPA: OAQPS 1977.
EPA 450/2-77-022	Control of Volatile Organic Emissions from Solvent Metal Cleaning.
EPA 450/2-77-025	Control of Refinery Vacuum Producing Systems - Wastewater Separators: Process Unit Turnarounds.
EPA 450/2-77-026	Control of Hydrocarbons from Tank Truck Gasoline Loading Terminals.
EPA 450/2-77-032	Control of Volatile Organic Emissions - Surface Coating Vol. III.
EPA 450/2-77-033	Control of Volatile Organic Emissions - Magnetic Wire Vol. 4.
EPA 450/3-73-003A	Emissions Control in the Grain and Feed Industry, Vol. 1. Engineering and Cost Study. 12/73. Midwest Research Inst. 1973.
EPA 450/3-73-003B	Emissions Control in the Grain and Feed Industry. Vol. 2. Emission Inventory. 9/74. Midwest Research Inst. 1974.
EPA 450/3-73-004A	Air Pollution Control in the Primary Aluminum Industry. Vol. 1 of 2 (Sections 1 through 10). 7/73. Singmaster and Breyer. 1973.
EPA 450/3-73-004B	Air Pollution Control in the Primary Aluminum Industry. Vol. 2 of 2 (appendices). 7/73.
EPA 450/3-74-002	Evaluation of the Controllability of Power Plants Having a Significant Impact on Air Quality Standards. 2/74.
EPA 450/3-74-015	Factors Affecting Ability to Retrofit Flue Gas Desulfurization Systems. 12/73. Radian Corp. 1973.
EPA 450/3-74-036A	Investigation of Fugitive Dust: Vol. I - Sources, Emissions, and Control. PEDCo Env. Specialists. 1974.
EPA 450/3-74-036B	Investigation of Fugitive Dust: Vol. II - Control Strategy and Regulatory Approach. PEDCo Env. Specialists. 1974.

EPA 450/3-74-060	Air Pollution Control Technology and Costs - Seven Selected Emission Factors. 12/74. Indust. Gas Cleaning Inst. 1974.
EPA 450/3-74-063	Particulate Emission Control Systems for Oil-Fired Boilers. 12/74. Geomet. 1975.
EPA 450/3-75-046A	A Study of Vapor Control Methods for Gasoline Marketing Operations. Vol. 1 - Industry Survey and Control Techniques. 4/75. Radian Corp. 1975.
EPA 450/3-75-046B	A Study of Vapor Control Methods for Gasoline Marketing Operations. Vol. 2 - Appendix. 4/75. Radian Corp. 1975.
EPA 450/3-75-047	Comparison of Flue Gas Desulfurization Coal Liquefaction and Coal Gasification for Use at Coal-Fired Power Plants. Kellogg MS Co. 1975.
EPA 450/3-76-005	Control of Particulate Matter from Oil Burners and Boilers. Aerotherm Corp. 1976.
EPA 450/3-76-013	Cost of Retrofitting Coke Oven Particulate Controls. Vulcan Cincinnati. 1974.
EPA 450/3-76-036	Evaluation of Methods for Measuring and Controlling Hydrocarbon Emissions from Petroleum Storage Tanks. Battelle Memorial Inst. 1976.
EPA 450/3-76-038A	Background Information on Hydrocarbon Emissions from Marine Terminal Operations: Vol. I - Discussion. Radian Corp. 1976.
EPA 450/3-76-038B	Background Information on Hydrocarbon Emissions from Marine Terminal Operations: Volume II - Appendices Radian Corp. 1976.
EPA 450/3-76-042	Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda. Little Ad. 1976.
EPA 450/3-77/-010	Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo Env. Specialists. 1977.
EPA 450/3-77-026	Atmospheric Emissions from Offshore Oil and Gas Development and Production, Energy Resources Co. 1977.
EPA 450/3-77-046	Screening Study to Determine Need for SOx and Hydrocarbon NSPS for FCC Regenerators.